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Planning Guidelines for Selecting Ridesharing Strategies

DOUGLAS W. WIERSIG

A set of planning guidelines for evaluating and selecting alternative ridesharing strategies in urban areas is described. The guidelines enable a detailed step-by-step analysis that begins by assessing the role of ridesharing in the study area and proceeds through market identification, alternative-strategy identification, strategy evaluation, and final program evaluation. The guidelines specifically address the topics of strategy evaluation and selection and do not deal with detailed implementation steps or issues. For each step in the evaluation process, a checklist and discussion of critical evaluation factors are presented so that each strategy is systematically evaluated and assessed relative to surrounding market conditions. Through use of the evaluation procedure presented in this research, a quick and comprehensive analysis of ridesharing options can be undertaken to determine those strategies with the greatest potential for increasing ridesharing rates and reducing vehicle miles of travel and energy use.

Transportation activities have changed significantly in recent years: emphasis has shifted from major highway construction and long-range master planning to a more diverse set of issues and concerns for achieving a set of short-term objectives. Ridesharing offers the chance to extend the use of existing transportation systems in ways that increase their efficiency while reducing the need for additional vehicles and roadway capacity.

Given this renewed interest toward ridesharing, transportation planners must have a thorough understanding of each alternative ridesharing strategy and be capable of identifying market segments that are best suited for successful implementation of a comprehensive ridesharing program. Because of diversity in strategies and the need for quick reaction in the time of crisis, planners are confronted with the difficult task of evaluating options under limited time frames and financial resources.

In order to define the role of ridesharing as an action to increase efficiency of existing transportation facilities, a well-defined set of planning and evaluation guidelines is necessary. To help fill this need, a set of planning guidelines has been developed with a step-by-step procedure for evaluating and selecting ridesharing strategies. These guidelines begin by assessing the role of ridesharing in the study area and proceed through market identification, alternative-strategy identification, and strategy evaluation. The guidelines specifically address topics of strategy evaluation and selection and do not deal with detailed implementation steps or issues.

EVALUATING RIDESHARING OPTIONS

The steps to be undertaken in evaluating and selecting ridesharing strategies are discussed below. The initial step of determining goals and objectives is carried out in conjunction with the overall transportation planning process in which transportation issues and problems have been identified. The purpose of this step is to determine whether ridesharing strategies address these issues and are capable of meeting desired goals and objectives.

Step 2 attempts to identify the role of ridesharing in meeting overall community goals by determining necessary participation levels. If ridesharing is expected to contribute a specified portion in communitywide energy reductions, it is essential to know whether these levels can realistically be attained. Determining necessary participation levels is also a key factor in the level of intensity and priority given to ridesharing. If the community or individual firm has elected to undertake a ridesharing program as their major means of reducing vehicle miles of travel (VMT) and energy use, determining participation levels identifies the degree of effort necessary to reach these desired reduction levels. Based on these participation levels and the resulting degree of effort, a decision can be made to proceed with the program at the specified level of intensity or adjust the reduction levels to coincide with acceptable intensity and funding levels.

Step 3 is directed at identifying market segments within the study area that are capable of supporting alternative ridesharing strategies. Market segments in this context can be groups of commuters with similar travel or socioeconomic characteristics or areas within the community that possess characteristics necessary for application of particular strategies. Through identification of market segments, potential strategies are then selected that have similar market characteristics. For example, if a heavily traveled corridor with a large volume of common origins and destinations exists, vanpooling and preferential lanes may be applicable strategies.

The next phase in the selection process, steps 4 and 5, is to access these potential strategies in a two-phase process of preliminary and detailed evaluation. Preliminary or first-cut evaluation (step 4) is oriented toward narrowing the range of strategies to be evaluated in detail to those strategies best suited to the study area and eliminating analyses of least-applicable strategies. Each strategy is assessed against five preliminary evaluation factors that address issues of compatibility with goals, objectives, and other transportation programs; political and public acceptability; availability of financial resources; and identification of supporting strategies.

The fifth step in strategy evaluation is a detailed evaluation of strategy costs, benefits, impacts, and institutional issues. This detailed evaluation enables a close examination of expected impacts and institutional issues that may arise and identifies quantitative and qualitative measures of cost and benefits that can be expected to occur.

The final step in strategy selection (step 6) is to combine strategies into workable programs and determine the most efficient set of strategies. In this selection phase, results from the previous two evaluation phases are combined to rate the effectiveness of various combinations of strategies.

Through following this evaluation framework and using the various resource procedures and assessment factors, a comprehensive analysis of ridesharing options can be performed. Material presented in the remaining sections focuses on the elements comprising the evaluation procedures in steps 2 through 6.

SUPPLY MODELS

An important element in developing and selecting ridesharing strategies is to determine the number of commuters needed to participate in ridesharing to achieve a desired level of travel reduction. Being able to estimate the necessary magnitude in ridesharing participation is beneficial in the early planning stages to identify whether desired reduction levels in VMT and energy use are feasible. Matching these supply estimates, which comprise step 2 of the planning guidelines, later with demand estimates of step 5 provides an assessment of the ability to reach desired reduction levels and the resulting level of program intensity. This in turn allows adjustments to be made to target reduction values to coincide with acceptable intensity and funding levels.

MARKET IDENTIFICATION

The initial step in selecting ridesharing strategies is to identify market segments that are capable of supporting alternative strategies. Market segments in this context refers to groups of commuters with similar travel and socioeconomic characteristics or areas within the community that possess characteristics necessary for application of a particular strategy. Based on this definition, market segments, for example, could be a group of commuters with a one-way travel distance greater than 15 miles or an area within the community where the demand for parking exceeds the supply. In these examples, strategies applicable to each market segment are vanpooling and parking-management techniques, respectively. Thus, by identifying potential market segments through commuter or community characteristics, each strategy can be evaluated as to its potential application in the study area based on common characteristics.

For most strategies to reach their greatest potential, certain characteristics must exist within the area of application. In the case of parking-management techniques, parking demand should exceed supply, whereas preferential-lane use requires a corridor with a large volume of common origins and destinations. This is not to say that these strategies will be successful in these areas or that they would not be applicable in other areas but rather indicates that the greatest potential exists in these areas and that further, more detailed evaluation is necessary before a final conclusion can be reached. In the identification of potential segments, the primary emphasis is directed at community rather than commuter characteristics since the success of a particular strategy is primarily dependent on the surrounding environment and the fact that few differences exist between single drivers and ridesharers in terms of socioeconomic and travel characteristics (1).

To aid decisionmakers in performing a market analysis, the important market characteristics have been summarized below; this list can be used as a checklist when identifying markets:

1. High-density employment centers,
2. High-density residential areas,
3. Commuter travel distances,
4. Heavily traveled corridors,
5. Areas of severe traffic congestion,
6. Areas of low parking supply, and
7. Working habits.

Table 1 summarizes market characteristics for each strategy and can be used as a quick reference guide. As a further aid in identifying market segments, a discussion of the important considerations of each characteristic identified is presented.

High-Density Employment Centers

Areas of high employment in most instances have the greatest potential for ridesharing activities since the number of commuters with common origins and destinations is usually the greatest. These areas also enable a large number of commuters to be contacted with minimal effort. As a result, carpool and vanpool programs are especially suited for these areas as well as other supportive strategies that rely on matching techniques. Large employment centers may also possess parking and congestion problems that could lead to the application of financial incentives, parking-management techniques, and flexible work hours.

High-density employment centers commonly found in urban areas include single large employers, industrial and office parks, regional activity centers, and the central business district (CBD).

High-Density Residential Areas

High-density residential areas like densely populated employment centers have a greater potential for a large number of commuters with common origins and destinations and consequently are target markets

Table 1. Market characteristics by strategy.

Strategy	Market Characteristic
Carpool matching program	Communitywide matching programs: medium and large urban area; site-specific matching programs: single large employer or concentration of large volume of employees (more than 500)
Vanpool program	Large single employer or concentration of employees (more than 500); one-way travel distance greater than 15 miles; no particular type of occupation more desirable; employer parking problems valuable incentive
On-street parking restriction	Parking demand exceeds supply; large employment center (CBD) or other area where on-street parking permitted and demand exceeds supply (hospitals, universities)
Off-street parking restriction	Parking demand exceeds supply; area where new development occurring or expected (restriction in new parking supply)
Residential parking control	Residential area within walking distance of CBD or other large employment center where spillover parking occurs (hospitals, universities)
Exclusive bus-and-carpool lane arterial	Large volume of common origins and destinations; corridors with bus volumes of 20-25/h; minimum of five travel lanes; length varies based on travel-time savings
Contraflow bus-and-carpool lane	Large volume of common origins and destinations; arterial streets with minimum of five travel lanes and bus volumes of 20-25/h; freeway bus volumes of 40-60/h
Reversible-lane system	Same as exclusive bus-and-carpool lane arterial
Freeway bus-and-carpool bypass	Large volume of ramp traffic; metered on ramps
Exclusive bus-and-carpool lane freeway	Large volume of common origins and destinations; corridors with bus volumes of 40-60/h
Special bus-and-carpool turning privilege	Area of severe traffic congestion and resulting travel-time savings
Vehicle toll	Existing toll facilities
Carpool and vanpool preferential parking	High demand for parking; excessive walking distance from parking lot; large employment sites
Parking-rate change	Area where land values and parking rates high (CBD)
Park-and-ride facility	Existing bus transit park-and-ride lots; heavily traveled corridor with single destination; large remote employment center with one-way commute distance greater than 10 miles; high parking cost at destination and low supply
Elimination of employer parking subsidy	Applicable to any type or location of employer; greater potential at site where land availability scarce or employer desires to expand physical plant
Employer financial incentive	Employers active in ridesharing, high parking costs, high demand for parking
Automobile-free or restricted area	Downtown area, one or two streets usually converted to shopping mall
Staggered or flexible work hours	Large single employer or concentration of employees; white-collar employment centers; areas with severe congestion problems

for carpool and vanpool programs. These areas also enable easy contact of a large number of commuters through neighborhood groups or apartment associations. High-density residential areas would most likely be large single apartment buildings or areas with a clustering of multifamily dwelling units.

Commuter Travel Distances

The incentive to rideshare is substantially greater for those commuters who have longer home-to-work travel distances. Early formation of pools enables a ridesharing program to grow visibly and builds momentum for addressing areas with less potential or with reluctance to participate in program activities. Strategies applicable to these areas might include carpool and vanpool programs, preferential lanes, and park-and-ride facilities.

The distance at which ridesharing becomes attractive is relative to the commuting characteristics of the community. If the study area is small and commute distances are short, a shorter distance will provide more incentive to rideshare than if the commute distances were longer. Longer commute distances can be determined by identifying remote employment and residential areas or suburban subdivisions that are located beyond the distance that makes ridesharing attractive in the study area.

Heavily Traveled Corridors

Corridors carrying a large volume of traffic to common destinations such as the CBD may be potential candidates for preferential lanes, park-and-ride facilities, and carpool and vanpool programs. To justify a reserved lane, the corridor must carry a greater number of people than that carried prior to reserving the lane. In most instances a preferential lane for carpool and vanpool use must be implemented only in conjunction with substantial express-bus service.

The length of reserved lanes can vary from 0.5 mile to greater than 10 miles; the major consideration is the resulting travel-time savings. Thus, reserved lanes can be located on heavily traveled corridors at areas of severe congestion such as interchanges and intersections or other areas where congestion occurs. In identifying these corridors, traffic volumes must not only be large but also be destined to a common area. If trip destinations are diffused along the corridor, reserved lanes become less effective because commuters travel less distance on the lane and experience a smaller travel-time savings.

Areas of Severe Traffic Congestion

Areas where severe traffic congestion occurs may be prime locations for the application of isolated priority techniques such as short-length reserved lanes or special turning privileges.

Areas where these techniques might be applicable include the CBD, industrial and office parks, large employers, and areas where turns are prohibited during rush hour. For each application to be successful, travel-time savings or relief from congestion should be substantial enough to influence commuters to rideshare.

Areas of Low Parking Supply

In areas where the demand for parking exceeds available supply, a number of parking-management techniques may be applicable. Areas most likely to exhibit a shortage in parking are high-density employment areas such as the CBD, regional activity centers, university areas, or industrial and office parks and large single employers. Parking techniques that are directly applicable include elimination of employer subsidies, increased parking rates, parking surcharge tax, and preferential carpool and vanpool parking. In many instances, complementing parking strategies must also be implemented to eliminate alternative, less costly, or more attractive parking spaces. These strategies include elimination of on-street parking and establishment of residential permit systems.

Working Habits

The general nature of the workforce and their working hours can influence the success of several strategies. Areas or employers that are production-oriented and dependent on others for the accomplishment of their work task are not well suited for flexible work hours. In general, white-collar employment centers are best suited for flexible work hours, since employees are less dependent on others and able to manage their time more freely to coincide with others for pooling. Flexible work hours may be applicable at manufacturing industries in certain cases and a closer analysis of the nature of the work may be necessary to fully assess its potential.

Toll Facilities

Exiting toll facilities such as bridges, tunnels, ferryboats, and toll roads should be identified in order to assess the possibility of providing preferential treatment or reduced tolls for ridesharers. If congestion occurs at toll plazas, preferential lanes on the approach road or reserved lanes on the facility may substantially reduce travel time for ridesharers. Ridesharers could also be given reduced or free tolls on the facility.

PRELIMINARY EVALUATION

After market segments have been identified and candidate strategies selected, a preliminary first-cut evaluation of each alternative is undertaken. The orientation in this first-cut analysis is toward narrowing the range of strategies for detailed evaluation to those best suited to the study area. Eliminating unacceptable strategies based on noncompatibility with community goals and transportation programs or lack of political or public support enables a streamlining of the evaluation process. To perform this preliminary analysis, each potential strategy is assessed against several major considerations that function as a checklist. In many instances where the study area is small and the number of alternative strategies few, preliminary evaluation will most likely be performed in conjunction with market identification. In any event, the following checklist of preliminary evaluation measures should be assessed against each strategy in the early stages of selection to avoid needless analysis of unacceptable strategies. Evaluation measures that should be considered include the following:

1. Compatibility with community goals and objectives,
2. Compatibility with current or proposed transportation programs,
3. Political and public acceptability,
4. Availability of financial resources, and
5. Identification of supporting strategies.

To emphasize the usefulness of these measures in screening strategies, a discussion of each follows.

Compatibility with Community Goals and Transportation Programs

To gain successful backing by community leaders and residents, strategies should be compatible with the goals and transportation programs of the area. If strategies conflict with goals or are counterproductive to existing or proposed transportation programs, extensive conflicts could arise that may jeopardize the success of any type of ridesharing activity.

The major area of potential conflict arises when existing or proposed transportation programs are considered. Ridesharing strategies can be in direct conflict with other transportation programs that, in the implementation stages, could initiate adverse public reaction toward ridesharing. An example of this situation can occur when vanpooling is implemented in a heavily traveled corridor that is now served by express-bus service. Vanpool implementation in this instance without considering express-bus service could cause a diversion of riders from transit and place the continuation of bus service in jeopardy.

Political and Public Acceptability

An essential element in the final selection and success of many projects is the degree of favorable support they receive from political decisionmakers and other influential community leaders. Several ridesharing strategies such as parking bans or increased taxes can easily meet rejection from community leaders and decisionmakers. Programs that alter common everyday commuting habits can experience quick failure if favorable community and political support is absent. In situations where community leaders oppose a strategy, decisionmakers are often faced with a politically sensitive decision that can result in the strategy's receiving little or no supportive backing, even though the program is favored by them. It is important that reactions from both community leaders and decisionmakers be considered, since the two may express different opinions and their influence on one another may affect decisions in later stages of selection and implementation.

Attitudinal assessments early in the selection process enable planners to avoid initiating negative reactions toward strategies that are often drawn out of proportion and consequently make it difficult to modify otherwise acceptable strategies.

Availability of Financial Resources

In formulating ridesharing programs, like other community projects, the availability of financial resources is critical in determining the scope and intensity. Identifying the availability and level of funding serves a dual role in developing and selecting strategies. First, it focuses the selection process on those strategies that are within the financial bounds and, second, it identifies whether limitations should be imposed on the scope of individual strategies to reduce their cost. Strategies such as preferential lanes or communitywide matching services can become extremely expensive and beyond the financial capabilities of many communities. As a result, the selection process should initially investigate the ability to finance strategies and disregard those that are too costly. Likewise, the scope and intensity of individual strategies may be adjusted so that costs may fall within financial limits.

Identification of Supporting Strategies

As a final step in preliminary strategy selection, a review of remaining strategies should be undertaken to identify whether the inclusion of supporting strategies will enhance the effectiveness of the total ridesharing program. In many situations, supporting strategies are essential to the success of other strategies and should be implemented to produce a strong incentive for ridesharing. For example, in the case of preferential parking for carpools and vanpools, some type of matching program is essential to provide a means of forming new ridesharing arrangements and successful use of reserved parking spaces.

DETAILED EVALUATION

The final stage in strategy evaluation is to perform a detailed analysis of remaining candidate strategies. Through preliminary screening, a list of possible strategies was narrowed to include only those that coincide with identified market segments and that presented no major obstacles to successful implementation. The objective in this detailed analysis phase is twofold; first, it enables a close examination of expected impacts and institutional issues that may arise and, second, it identifies quantitative and qualitative measures of costs and benefits that can be expected to occur.

To perform this detailed strategy evaluation the following measures should be considered:

1. Legal and regulatory issues,
2. Impacted community groups,
3. Implementation time,
4. Program costs, and
5. Estimated demand.

Through assessing each strategy against these measures, specific costs, benefits, and impacts can be determined, which in turn become the basis for strategy comparison and final program selection. In addition to being used for final program selection, these results provide a means of determining whether strategy modifications would enhance their effectiveness.

As an output of assessing these evaluation measures, a list of final candidate strategies should be assembled that have been closely screened to ensure their applicability to the study area and absence of major implementation barriers. To emphasize the usefulness of these evaluation measures, a discussion of each follows.

Legal and Regulatory Issues

Legal and regulatory problems concern the passage or modification of ordinances and regulatory actions that enable legal implementation of strategies. Strategies such as parking controls may require deregulation by the state public service commission. Legal and regulatory problems may vary from state to state and even from city to city, since regulatory structures and state and municipal statutes vary. Thus, each application must consider local conditions when these issues are addressed. Table 2 identifies possible problems that may be confronted for each strategy and is broken into five groups of issues.

Determining institutional issues and the level of effort necessary to correct them is critical to final selection and programming of strategies. If issues are too cumbersome or political pressures too great to be realistically overcome, associated strategies can be eliminated from further consideration.

Impacted Groups

Identifying community groups affected by ridesharing strategies and the type of expected impact plays an important role in strategy selection and emphasis. If candidate strategies are expected to cause severe negative impacts, their initial deletion may be desirable to avoid jeopardizing the success of other ridesharing efforts as well as the future application of the strategy. Determining potential impacts is also useful during implementation, since project staff can anticipate negative impacts and be prepared with alternative actions.

In addition to identifying negative impacts, many positive attributes are associated with ridesharing that are essential in developing political and community acceptance. Expected benefits associated with the application of all strategies include reduced energy consumption, reduced pollution, increased use of existing roadways as well as elimination of the need for building additional facilities, reduced absenteeism, and increased employee morale. Table 3 lists expected impacts for each strategy for six frequently affected groups.

Implementation Time

The timing and scheduling of ridesharing strategies have two dimensions. First, the time period required to implement a particular strategy is dependent on the complexity of the strategy and the incremental time period for planning, design, and

Table 2. Legal and regulatory issues by strategy.

Strategy	New or Revised Municipal Ordinance	State Regulatory or Legal Enabling Legislation	Insurance	Employee Labor Agreement	Change in Municipal Building Costs	Transit Agreements and Arrangements
1. Carpool matching program			Increases or decreases in rates for those ridesharing	Possible inclusion as employee fringe benefits and labor agreements		Inclusion of transit information on matching lists
2. Vanpool program		Deregulation of vanpools by state public utilities commission	Establishment of insurance classification and rates	Same as strategy 1		Section 13(c) agreements
3. On-street parking restriction	Legal authority to restrict parking by municipal government					Coordination of transit routes with parking restrictions; availability of transit capacity to handle additional riders
4. Off-street parking restriction	Same as strategy 3	State-enabling legislation			Legal authority to limit parking space requirements for new buildings	Availability of transit capacity to handle additional riders
5. Residential parking control	Same as strategy 3	Same as strategy 4				Same as strategy 4
6. Exclusive bus-and-carpool lane arterial	Legal authority to enable reservation of exclusive lanes by ridesharing modes from local municipality	Legal authority to enable reservation of exclusive lanes by ridesharing modes from state department of transportation or legislature				Coordination of transit services on corridor
7. Contraflow bus-and-carpool lane	Same strategy 6	Same as strategy 6				Same as strategy 6
8. Reversible-lane system	Same as strategy 6	Same as strategy 6				Same as strategy 6
9. Freeway bus-and-carpool bypass	Same as strategy 6	Same as strategy 6				Same as strategy 6
10. Exclusive bus-and-carpool lane freeway	Same as strategy 6	Same as strategy 6				Same as strategy 6
11. Special bus-and-carpool turning privilege	Same as strategy 6	Same as strategy 6				Same as strategy 6
12. Vehicle toll	Legal authority to change or charge tolls	Legal authority to change or charge tolls				Same as strategy 6
13. Carpool and vanpool preferential parking				Same as strategy 1		Coordination with available transit services
14. Parking-rate change	Legal authority to change rates by local municipality					Same as strategy 4
15. Park-and-ride facility	Legal authority to enable parking facilities and contracts for joint-use lots		Liability at parking facilities			Same as strategy 13
16. Elimination of employer parking subsidy				Possible issue in labor negotiations		Same as strategy 13
17. Employer financial incentive				Same as strategy 1		Same as strategy 13
18. Automobile-free or restricted area	Legal authority to restrict traffic					Same as strategy 13
19. Staggered or flexible work hours				Same as strategy 1		Same as strategy 13

Table 3. Ridesharing impacts by affected groups.

Strategy	Nonusers	Transit Services	Employers	Retail Merchants	Shoppers	Municipal Costs	Other Impacts
1. Carpool matching program		Possible diversion of riders	Administrative cost; liability in case of accident	Increase sales since commuters less able to shop in other areas	Increase parking spaces	Administrative cost of program	
2. Vanpool program		Diversion of riders	Administrative cost; liability in case of accident		Increase parking spaces	Administrative cost of program	
3. On-street parking restriction	Reduce number of parking spaces	Better movement for buses; increase incentive to use transit		Increase attractiveness of shopping in area	Increase short-term spaces	Reduce parking revenues if park-eliminated; increase revenue if short-term parking available	
4. Off-street parking restriction	Reduce number of parking spaces	Increase incentive to use transit		Increase or decrease attractiveness of location	Increase or decrease parking spaces	Same as strategy 3	
5. Residential parking control	Reduce number of parking spaces	Increase incentive to use transit				Administrative cost of program	
6. Exclusive bus-and-carpool lane arterial	Decrease travel time if use high; increase travel time if use low; prohibit turning movements	Decrease transit travel time divert transit riders		Decrease access to fronting stores; loss of on-street parking	Decrease access to abutting land uses; loss of on-street parking	Capital, maintenance, and enforcement costs	Increase traffic on alternate routes
7. Contraflow bus-and-carpool lane	Same as strategy 6	Same as strategy 6				Same as strategy 6	
8. Reversible-lane system	Same as strategy 6	Same as strategy 6				Same as strategy 6	
9. Freeway bus-and-carpool bypass	Slightly increase travel time	Same as strategy 6				Same as strategy 6	
10. Exclusive bus-and-carpool lane freeway	Same as strategy 6	Same as strategy 6				Same as strategy 6	
11. Special bus-and-carpool privilege		Same as strategy 6				Same as strategy 6	
12. Vehicle toll	Object to toll increase	Divert transit riders				Reduce revenue's ability to meet bond payments	
13. Carpool and vanpool preferential parking	Increase walking distance		Administration of program				
14. Parking-rate change	Increase parking rate	Same as strategy 4		Same as strategy 4	Same as strategy 4	Increase tax revenues or decrease in revenues if demand decreases	
15. Park-and-ride facility	Increase parking at work destination	Possibly divert riders with matching from lots		Increase sales from lot users		Administrative and maintenance costs	Air, noise pollution around parking facility; additional traffic congestion if lot large with substantial transit service
16. Elimination of employer parking subsidy	Eliminate parking spaces or additional cost of paying for parking	Same as strategy 4	Eliminate cost of providing parking; use land for other company purposes			Increase property tax from higher assessed value of property if used more productively	
17. Employer financial incentive	Equality of incentives since some employees unable to form pools	Same as strategy 4	Cost of incentive and administration				
18. Automobile-free or restricted area	Restrict areas of travel	Same as strategy 4		Revitalize area and increase retail sales	Increase attractiveness of shopping areas	Construction and maintenance costs	
19. Staggered or flexible work hours	Increase flexibility of working times	Spread out peak loads; better use of resources	Initial administration costs			Initial administration costs	Increase use of vehicle for shopping and other trips as result of flexibility in work times

construction. The second dimension is the period after implementation where commuters adjust to the new conditions and modal changes are made. Estimating expected implementation and adjustment periods enables selection of strategies that fall within the program time frame. Table 4 lists expected implementation times for each ridesharing strategy.

Identifying implementation and adjustment time periods enables the programming and selection of strategies expected to produce increases in ridesharing early in the program. Selecting strategies that increase ridesharing demand early tends to stimulate community interests in ridesharing and maintains a commitment toward ridesharing by decisionmakers.

Table 4. Implementation time by strategy.

Strategy	Implementation Time
Carpool matching program	Communitywide: 6-12 months Employer program: less than 6 months
Vanpool program	Communitywide: 1-2 years Employer program: 6-12 months Third party: 1-2 years
On-street parking restriction	Less than 6 months
Off-street parking restriction	6-12 months
Residential parking control	6-12 months
Exclusive bus-and-carpool lane arterial	Take-a-lane: 6 months to 2 years Add-a-lane: 1-5 years
Contraflow bus-and-carpool lane	6 months to 2 years
Reversible-lane system	6 months to 2 years
Freeway bus-and-carpool bypass	6-12 months
Exclusive bus-and-carpool lane freeway	Take-a-lane: 1-5 years Add-a-lane: 2 to more than 5 years
Special bus-and-carpool turning privilege	Less than 6 months
Vehicle toll	6-12 months
Carpool and vanpool preferential parking	Less than 6 months
Parking-rate change	6-12 months
Park-and-ride facility	6 months to 2 years
Elimination of employer parking subsidy	6-12 months
Employer financial incentive	6-12 months
Automobile-free or restricted area	1-5 years
Staggered or flexible work hours	Less than 6 months

Program Costs

Implementation costs for ridesharing strategies include the cost of planning, design, and construction. Costs can also be broken into two categories--direct and indirect program costs. Direct costs are those of capital outlays such as planning, design, administration, and annual program costs, whereas indirect costs are user and nonuser costs and the cost to participating employers for administration and incentives. From the standpoint of formulating a program budget on a municipal level, direct costs are of primary interest, since indirect costs are not usually financed with municipal monies. Even though indirect costs are not borne by local governments, their consideration is important, since program participation by employers and users is dependent on the cost incurred by them and is also included in final economic analyses. Program costs can vary considerably for certain strategies, depending on their scope and intensity. For example, park-and-ride facilities can vary from joint-use lots, where construction costs are merely signing and striping, to construction of expensive new parking lots. Table 5 lists associated costs for each type of strategy from past applications in 1979 dollars.

Estimated Demand

Determining the expected increases for ridesharing modes is important, yet they are difficult to estimate. Estimating mode-split changes is a key factor in strategy selection since determining the most ef-

Table 5. Ridesharing program costs.

Strategy	Program Cost (1979 $)
Carpool matching program	Communitywide: $100 000-$150 000 annually for medium-sized city; $50 000-$100 000 for small urban area Employer sponsored: $5000-$45 000, start-up costs; moderately well-organized, promotion/matching program, $12 000 in staff and materials; $4000-$10 000, annual administrative costs
Vanpool program	Communitywide: $60 000, initial start-up; $40 000-$60 000, annual fixed costs plus $500/van/year operational; initial cost of vans not included in start-up costs Employer sponsored: $18 000-$35 000, start-up and organizational cost plus cost of vans; $25 000, average; $250-$350/van/year, administrative cost Third party: $65 000-$130 000, start-up plus cost of vans; $70 000-$90 000, annual fixed costs plus $60-$80/van/year, administrative costs
On-street parking restriction	Initial planning and signing costs, $50-$75/sign; minimal annual maintenance costs (sign replacement)
Off-street parking restriction	Initial planning costs vary considerably with intensity of program, from 1-2 months to 1-2 years; minimal annual costs
Residential parking control	$8000-$15 000 initial cost for planning, signing, issuing permits; $6000-$12 000 annual cost for sign replacement and issuing new permits
Exclusive bus-and-carpool lane arterial	Take-a-lane: $20 000-$50 000/mile signing, striping, minor construction; add-a-lane: $160 000-$250 000/mile (does not include right-of-way); $12 600-$38 000/mile annual operation and maintenance
Contraflow bus-and-carpool lane	Take-a-lane: $20 000-$50 000/mile signing, striping, minor construction; add-a-lane: $160 000-$250 000/mile (does not include right-of-way); $12 600-$38 000/mile annual operation and maintenance
Reversible-lane system	$5000-$10 000/mile signing and striping
Freeway bus-and-carpool bypass	$4000-$8000/ramp for signing and striping; $10 000-$80 000/ramp for widening and signalization
Exclusive bus-and-carpool lane freeway	Take-a-lane: $10 000-$30 000/mile signing and striping; add-a-lane: $2.5-3.5 million/mile (does not include right-of-way); $10 000-$30 000/mile operation and maintenance
Special bus-and-carpool turning privilege	Minimal signing/signal installation and striping costs, $1000-$5000 per application
Vehicle toll	Minimal administrative and promotional cost, $5000-$10 000
Carpool and vanpool preferential parking	Employer program: minimal signing and administrative costs, usually included in planning and administrative cost of carpool and vanpool program Municipal program: $8000-$10 000 start-up promotion, application processing, signing, and other materials; $1000-$5000 annual cost
Parking-rate change	$8000-$12 000 initial administrative cost, minimal annual costs
Park-and-ride facility	$380-$1200/space, avg $550/space initial construction cost; $15-$23/space annual maintenance
Elimination of employer parking subsidy	$3000-$6000 initial employer administrative cost
Employer financial incentive	Initial start-up and annual administrative cost included in cost associated with carpool and vanpool programs; additional cost of incentives should be added to these costs
Automobile-free or restricted area	$75 000-$4 000 000 initial construction costs; $10 000-$50 000 annual maintenance costs
Staggered or flexible work hours	$4000-$12 000 initial set-up and administrative cost; no annual costs

Table 6. Observed ridesharing demand by strategy.

Strategy	Observed Ridesharing Demand
Carpool matching program	Communitywide: 1-2.5 percent increase in areawide carpool share Employer program: 4-10 percent increase in carpooling
Vanpool program	Communitywide: 1-2 percent increase in areawide vanpool share Employer program: 5-22 percent increase, average 8 percent increase
On-street parking restriction	No reported results except those for on-street carpool spaces (see carpool and vanpool preferential parking)
Off-street parking restriction	No reported ridesharing results; increase in transit ridership as result of restriction in growth of parking supply
Residential parking control	No reported ridesharing results; eliminate on-street parking by commuters substantially; increased use of off-street parking facilities available
Exclusive bus-and-carpool ane arterial	16 percent increase in vehicle occupancy
Contraflow bus-and-carpool lane	9 percent increase in vehicle occupancy
Reversible-lane system	100 percent increase in carpool use (three or more occupants per vehicle)
Freeway bus-and-carpool bypass	5-50 percent increase in new carpools, 30 percent average (higher values associated with two-person carpools)
Exclusive bus-and-carpool lane freeway	4.0-14.7 percent increase in vehicle occupancy, 6.0 percent average
Special bus-and-carpool turning privilege	No reported results
Vehicle toll	58 percent increase in number of carpools (18 percent per year)
Carpool and vanpool preferential parking	22-30 percent increase in new carpools at municipal lots and on-street parking; 17-29 percent increase in new carpools at individual employers
Parking-rate change	6 percent increase in vehicle occupancy as result of increased parking rates
Park-and-ride facility	45 percent increase in number of carpools at remote freeway lots
Elimination of employer parking subsidy	8-10 percent reduction in drive-alone commuters
Employer financial incentive	4-10 percent increase in carpooling; 5-20 percent increase in vanpooling
Automobile-free or restricted area	No reported results
Staggered or flexible work hours	No reported results

fective strategies is critical for a successful program. Existing techniques fall into two groups: (a) those that estimate potential ridesharing demand through sophisticated mode-split models or quick-response manual methods and (b) market-identification methodologies that identify commuter segments having a high potential for ridesharing based on travel cost, time, and distance characteristics but provide no estimate of expected participation levels from these commuters.

Three quick-response techniques are suggested for determining demand--the Department of Energy (DOE) manual method, local administered surveys, and results from applications in other communities (2). In cases where sufficient time and financial resources are available, a locally administered survey is recommended for estimating expected proportions. If candidate strategies are politically sensitive, such as parking taxes or bans, and it is anticipated that they would create public concern and pressures if presented in a survey, it is suggested that demand estimates be made through use of the DOE manual method rather than through a local survey. A local survey should provide the most efficient and reliable estimates of expected participation levels, since values are determined from local commuter responses rather than sophisticated modeling techniques or changes that occurred from applications in other areas.

In situations where resources are not available for local surveys or candidate strategies are politically sensitive, demand can be estimated through use of the DOE manual method or by using measured changes from applications in other communities. Table 6 lists observed results from application of various strategies in other areas.

STRATEGY SELECTION

In the preliminary and detailed evaluation phases, numerous evaluation and impact measures were assessed against each strategy. Through this analysis, costs, impacts, and specific values were associated with these measures and now become the primary means for comparing and selecting strategies. Techniques that are suggested for use include economic efficiency analysis (benefit/cost ratio, present worth, rate of return) and scoring methods. Through determining these summary measures, the most effective group of strategies can be selected and programmed for implementation.

SUMMARY

In developing a ridesharing program, many alternative ridesharing strategies can be identified for a study area that possess varying degrees of acceptance based on community characteristics and commuting patterns. Each strategy or group of strategies will result in different types and degrees of impacts as well as effectiveness in encouraging new ridesharing arrangements. To ensure selection of the most effective strategies, a systematic analysis of alternatives should be undertaken. In selecting strategies, a thorough analysis of the study area should be performed so strategies are applied to market segments most suited for their successful implementation. To enable this type of analysis, a well-defined set of planning guidelines should be followed so that essential factors are not overlooked when alternative ridesharing strategies are evaluated and selected.

Guidelines developed in this research provide this type of analysis structure and should be used as a guide in assessing ridesharing options. The guidelines, through supply models and assessment factors in market identification and preliminary and detailed evaluation phases, provide a quick response resource guide to systematically analyzing the critical issues facing successful implementation of ridesharing strategies. Through use of these guidelines, planners can quickly undertake a comprehensive analysis of ridesharing options.

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Developing Ridesharing Law: A First Step to Privatizing Transportation

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During the last five years, interest in ridesharing, especially vanpooling, has been rapidly growing. Before an organization decides to become involved in a ridesharing program, they usually ask their legal staff for an opinion on the liability, tax, insurance, wage and hour standards, and other consequences. It is then that they realize that ridesharing is a legal nonentity, so the law that applies to the pool is the law that developed for other purposes. The crucial legal test is whose name is on the vehicle title. This article examines a hypothetical vanpool with 12 passengers that is ready to start operation. The vehicle has been selected, the routes and fares have been determined, passengers and driver identified, and vanpool rules established. The only thing necessary is to decide whose name should be placed on the title of the new van. The vanpool group approaches the employer, the local transit authority, and two lease firms, considers incorporation, and asks the driver to accept title to the vehicle. In each case a totally different body of law applies, which ranges from lease law to common carrier law to labor law. Five legislative areas are suggested that need to be addressed before a body of ridesharing law is established. The development of ridesharing law would not only benefit ridesharing but would also be the beginning of privatizing public transportation for human service agencies.

The energy shortage and reduced public funding have focused public attention on one of the easiest and most effective conservation methods available--ridesharing. Unfortunately, our nation's legal system does not have a body of law to allow such cooperative endeavors; thus, ridesharing efforts encounter many institutional obstacles that will eventually have to be addressed if ridesharing is to reach its full potential.

This paper was prepared to assist the reader in conceptualizing these institutional barriers so that ridesharing programs can be structured to avoid them and to help policymakers understand the necessary changes.

Ridesharing commonly appears in three forms: carpooling, vanpooling, and buspooling. Vanpooling is simply carpooling by using a 12- or 15-passenger van instead of a 6-passenger car. A buspool is identical except that a bus is used. Carpools (and vanpools) can be either shared driving (each passenger takes a turn driving) or shared expense (one vehicle is used each day and all riders share the cost of operating the vehicle).

Ridesharing not only reduces energy use but also reduces public deficits in several ways:

1. Usually, the ridesharing vehicle is garaged at the employment site once the employees arrive at work and is usually garaged at the driver's residence after the employees return home;
2. Usually, a small vehicle, such as a station wagon or van, reduces the time necessary to gather a full load; therefore, the travel time approximates that of single-occupant automobiles; also, smaller vehicles usually use less fuel; and
3. Usually, the vehicles used are relatively inexpensive and are therefore easier for individuals, government, and employers to purchase; the vehicles will usually be driven from 10 000 to 20 000 miles/year; therefore, a vehicle with a design life of 1 million miles or more (as in the case of a transit bus) is not required; standard production-line vehicles can be used and large public investments are not needed.

Since carpooling and vanpooling are basically informal arrangements among neighbors, friends, and fellow employees, the service can readily adapt to the changing needs of the commuters. Because of this, it is generally much better to allow the driver to take the responsibility for routing and scheduling.

Since the drivers of the ridesharing vehicles are usually fellow employees who would be spending this time driving to and from work anyway, there is virtually no labor cost. Reduced commuting cost and potentially supplemented income usually motivate the drivers of ridesharing vehicles.

OPTIONS FOR PROVIDING RIDESHARING VEHICLES

As ridesharing arrangements become more formalized, there is often an opportunity to use vans in which 12-15 people can ride. Although many individuals have automobiles, less than 1 percent of the population have vans, especially those seating 12-15 passengers. Therefore, if a group of 10-15 people find that they live in the same neighborhood, work for the same or neighboring employers, have the same work schedule, and desire to ride together, a very important question becomes, "How do we obtain a vehicle so we can start vanpooling?"

There are generally five ways of obtaining vanpool vehicles:

1. The employer can provide the vehicle;
2. The government, usually through an agency such as a regional transportation authority, can provide the vehicle;
3. An independent company can provide the vehicle;
4. An individual employee can provide the vehicle; or
5. The individual can form a corporation to own the vehicle.

Consider, for example, the hypothetical case of 12 commuters living in a suburb 20 miles from their worksite; being concerned about fuel costs, energy efficiency, congestion, parking, pollution, etc.; and, after listening to numerous public service announcements, having decided to do something personally to help solve these problems. They decide to start a vanpool and to share in the cost of operating the van. They are now ready to find a vehicle. The 12 commuters approach their employer, the local transit authority, a lease firm, and a third-party provider. They consider incorporating, and they consider having one member of the pool buy the vehicle.

This paper is designed to illustrate the barriers to each option. A legal system that fails to recognize ridesharing as a legitimate human endeavor creates these barriers. The body of law that applies to vanpooling is dictated by vehicle title. By changing the name on the vehicle title, the members of the vanpool can alter the body of law that will apply from employer-employee law to common carrier transportation law to leasing law to corporate law to business law or to some other legal theory. After the implications of each option have been examined and the institutional concerns have been identified, the five legal philosophies are described that must be addressed to develop a body of ridesharing law so that ridesharing is not forced into inappropriate legal categories due solely to the name on the legal title.

Employer-Provided Vehicle

When the commuter group approached the employer, they were told that vanpooling was a good idea, but that the company's legal department was concerned about several issues, discussed below.

Workers' Compensation

If purchase of the van were considered an extension of the workplace, the passengers would be covered under workers' compensation. The workers'-compensation laws hold the employer strictly liable for all injuries occurring to employees within the scope of employment. Since workers'-compensation insurance premiums are based on payroll size, the workers'-compensation rates should not be increased. However, if a major accident occurred, it would raise the rates on workers' compensation for the firm's entire workforce, since workers'-compensation rates are based on the prior year's losses. Also, since workers'-compensation benefits are very low in some states, the passengers may not be adequately compensated in case of a major accident. Furthermore, even if the employees are protected by workers' compensation, the van rider may still be able to sue the driver of the vehicle if the state does not recognize the fellow-servant doctrine and/or prohibit such a suit under workers'-compensation statutes. Thus, the driver may still want to have individual liability coverage, since the driver's personal automobile coverage may not apply to regularly driven vehicles owned by the employer.

Employer Liability

If the van were not considered to be an extension of the workplace, the employer, like the driver, would be liable for damages that injure the commuters. Even if workers' compensation did apply, the company would have to buy insurance coverage to protect the company in case of accidental harm to those outside the vehicle who would not be covered by workers' compensation. In essence, existing laws assume that it is the employee's responsibility to get to work and that the employer will not become involved unless it is a necessary part of the business, as in the case of the transportation of migratory farm workers, who may not otherwise have transportation. Therefore, the employer may be required to assume full liability for all accidents to the passengers, the driver, and other parties if the employer is named on the vehicle title.

Taxation

Since the law assumes that the employer will not become involved in employee transportation unless it is essential for the operation of the business, monies spent on employee transportation are considered an ordinary business expense, similar to parking costs. Therefore, expenses related to the providing of transportation and the expenses related to the actual possession of the vehicle would be deductible expenses under the Internal Revenue Code. The employer, of course, would have to maintain detailed accounting records to verify the amount of expenses, depreciation, and tax credits claimed. The employer would also be eligible for a tax credit under Article 26, U.S. Code 46(6)(B), if the van fits within the definition of a commuter highway vehicle.

Discrimination

Since employer-provided transportation is considered by law as a benefit to employees, the employer has to be concerned about discrimination. First, tax laws specifically discourage discrimination on benefits because they can be used as tax-avoidance techniques for company owners and officers. For example, a company cannot give medical benefits to the owners and/or officers but deny coverage to other employees. Second, if an employer provides benefits for one group of employees and not for other employees, employee morale may suffer. Current laws and regulations treat ridesharing activities as employee benefits, not as a public service effort to accomplish public objectives.

Collective Bargaining

Since ridesharing support activities are not considered to be a public service, ridesharing may become a collective-bargaining issue. Until both labor and management jointly decide that vanpooling is a mutual social benefit and define the rules in advance, the employer is rightfully concerned that the group (either the company or the employees) that initiates vanpooling programs will end up absorbing the full cost. Therefore, each group wants to wait for the other group to initiate the program and thereby incur the cost.

Financial Risk

By purchasing the vehicle, the employer assumes all the financial risk. If the ridesharing group could not maintain payments or if the vehicle were stolen or damaged, the employer would incur the loss. Fortunately, few vanpools fail.

State Fair-Labor Laws

At the federal level, vanpools have been declared exempt from the federal standard wage and hour laws. Most states have adopted the same standards as those used by the federal government. Therefore, this ruling, in effect, changed the state laws. In the states that do not use the federal standard, the commuters may have to be paid overtime for the time spent traveling to work.

Limited to Large Employment Centers

If the employer purchases the van, individuals who work for a different employer nearby may have difficulty participating, since the first employer's workers'-compensation coverage would not cover them. Also, if some of the riders are not employees of the firm owning the vehicle, the vehicle no longer satisfies the definition of commuter highway vehicle that allows the accelerated investment tax credit. Then the employer must deny neighbors and spouses the opportunity to ride or incur total liability for their safety and jeopardize the investment tax credit.

Regulation

Until recently, the employer had to provide the vehicle without charge or become a regulated for-hire carrier. Recently, many state laws have been changed. In 1978, all vanpool trips that crossed state lines were exempted from Interstate Commerce Commission (ICC) regulation. In 1979, the National Committee on Uniform Traffic Laws and Ordinances drafted a model state ridesharing law that is now being considered by many states. In general, the regulating barriers in most states have been removed.

Government-Provided Vehicle

After hearing the employer's concerns regarding the implications of using the company's name on the title (or lease), the group of commuters decided to approach the local transportation authority, which they felt was responsible for solving commuter transportation problems. The executive director of the transportation authority explained that transit was operated under an entirely different body of laws. It was explained that the subway, the commuter trains, and transit bus lines were originally operated by private "for-profit" commercial companies as public utilities and that these franchised carriers were expected to serve all people without discrimination, to serve both profitable and unprofitable groups, to hold extensive public hearings regarding service and fare changes, and to abide by special protective labor and liability laws. When the private commercial for-hire companies were no longer financially able to provide service, they were purchased with public funds. The public system, in addition to assuming all existing regulations and obligations of the private companies, has also been subjected to requirements under public ownership, such as those discussed below.

Common Carrier Liability Standard

The law requires the transit authority to exercise extreme care to protect the passengers as opposed to the ordinary care required of the driver of a privately owned vehicle. This raises a question. If the transit authority is named owner on the title, does this subject the vanpools to the same legal standard of care as the remainder of the bus operation? If so, the authority would want to have very tight control over how the vehicle was used and how the driver was selected, and many other issues would have to be addressed. Also, because of the greater suit consciousness toward public transportation vehicles, the insurance cost would probably be much higher than that under any other ownership option.

Government Regulation

Under the public utility philosophy, there is social obligation for the transportation authority to provide services to all areas, including areas of limited demand, regardless of operating losses. This raises the question of government subsidization. If commuting areas started vanpools but did not have sufficient ridership to cover the cost of operating them, would it be as difficult for the authority to drop an unprofitable van as it is to drop an unprofitable bus run? Other questions, such as control over the use of publicly owned vehicles, are raised. Can the authority allow publicly owned vehicles, especially those on subsidized routes, to be used by drivers on evenings and weekends? If so, how is this use to be controlled? To what degree would authority vehicles be required to prove that they are not in competition with private providers, charter operations, or existing transit operations? What reporting requirements would be imposed? Would public meeting and notification requirements have to be met each time a van was added (or dropped) or a route changed due to changes in ridership? What if the destination (home or work) were outside the local transit district? Would the vans be able to operate there? Would the local community be willing to use local tax dollars to provide service to nonresidents? If the surrounding communities were asked to contribute toward the administration of the vans, would these communities see this as a means of getting other communities to subsidize the city's transit deficits? If the transportation authority is the titled owner, many questions must be addressed and many are very unclear at this time.

Section 13(c) Agreements

If the transit authority obtained public funds for vanpools, would this require negotiations with local transit unions pursuant to the Urban Mass Transportation Act (P.L. 88-365) in order to "protect employees from any adverse effect" resulting from vanpool operations? Would the vanpool drivers themselves become "protected employees" and become part of the labor protection agreements when transit service changes are made? For-hire commercial carriers have an extensive history of labor protection agreements that have been substantially strengthened with the public takeover of these companies. These issues raise many questions.

Public Use and Noncompetition

What if a vanpool driver decided to use the transit authority van to take a group of Boy Scouts to a campout at the state park, a group of parents to a high school football game, or senior citizens to a church supper? Would this be considered illegal charter service and in competition with local charter bus operators? Would the authority authorize this type of service? If so, how should fares be set? If the activity is authorized, would the driver be allowed to donate driving time or would the driver be required to be an employee to provide this service? If the driver is an employee, can the driver be assigned without having to go through his or her turn as an extraboard and take assignments in turn with other drivers?

Financial Loss

If the authority owned the vehicle, the authority would bear the financial risk of loss if the vanpool failed. The authority might be able, however, to give the vehicle to another group of commuters if it is politically acceptable to remove service on which individuals have become dependent.

Tax Considerations

Vanpooling under the authority should be completely exempt because most authorities are nonprofit organizations. Revenue would not be taxable. Vehicles would be exempt from sales tax, license fees, property tax, and possibly fuel tax and may even be eligible for federal and state subsidies as transit vehicles are. When vehicles are shifted from one commuter group to another, there would be no registration fees, sales tax, or other costs of transferring the vehicle between commuting groups.

Discrimination

The fundamental principle of the regulation of for-hire commercial transportation is the avoidance of discrimination. The word "discrimination" in transportation law differs from that in the civil rights context. Discrimination means the providing of a different level of service or the charging of a different fare to any person, geographic region, or for any type of trip.

The importance of discrimination in transportation can be seen by reviewing certain sections of the ICC Act. For example, 49 U.S. Code Supplement, Section 10101, states that the "Transportation Policy" includes the encouragement of establishing and maintaining "reasonable rates for transportation without unreasonable discrimination or unfair or distinctive competitive practices." Section 49, U.S. Code Supplement, Section 10741, provides as follows:

> (a) A common carrier providing transportation subject to the jurisdiction of the Interstate Commerce Commission under subchapter I of chapter 105 of this title (49 USCS § 10501 et seq.) may not charge or receive from a person a different compensation (by using a special rate, rebate, drawback, or another means) for a service rendered, or to be rendered, in transportation the carrier may perform under this subtitle than it charges or receives from another person for performing a like kind of traffic under substantially similar circumstances. A common carrier that charges or receives such a different compensation for that service unreasonably discriminates.
>
> (b) A common carrier providing transportation or service subject to the jurisdiction of the Commission under chapter 106 of this title (49 USCS § 10501 et seq.) may not subject a person, place, port, or type of traffic to unreasonable discrimination. However, subject to subsection (c) of this section, this subsection does not apply to discrimination against the traffic of another carrier providing transportation by any mode.
>
> (c) A common carrier providing transportation subject to the jurisdiction of the Commission under subchapter I, II, or III of that chapter (49 USCS § 10501 et seq., 10521 et seq., or 10541 et seq.) may not subject a freight forwarder providing service subject to the jurisdiction of the Commission under subchapter IV of that chapter (49 USCS § 10561 et seq.) to unreasonable discrimination whether or not the freight forwarder is controlled by that carrier.

Therefore, the authority would have to be careful not to discriminate between groups. If vans were made available for long-distance commuters, they might have to be made available for short- and intermediate-distance commuters. Should vans be withheld from areas served by transit or private operators for competitive reasons or should they be offered in order to avoid charges of discrimination? This question also must be addressed.

Liability

With the decline in governmental immunity, authority ownership of the van could make the authority fully liable to the passengers for all accidents as well as to the driver and other persons involved in a van accident. The authority would probably be required to have workers'-compensation coverage for the driver in addition to liability insurance. The authority would also find that suit consciousness and the resulting insurance cost would probably be much higher because of the common carrier liability standards associated with the transit authority (i.e., individuals are probably much more willing to sue when the van is owned by the authority than when it is owned by a neighbor or their employer).

The legal philosophy under which transit authorities developed generally assumed that the authorities were designed to take over, operate, and replace the traditional commercial for-hire carriers that operated the buses or subways, like the private transportation utility. These laws and regulations leave many questions that need to be resolved before regional authorities should consider commuter-van ownership. (It is easy to understand why some transit authorities have been reluctant to purchase vans and start vanpool programs.)

Independent Provider of Vehicle

After discovering all the legal implications of having vehicles owned by the regional transportation authority, the group decided to approach a private business to obtain a van. Here they discovered that there were two distinct ways in which a private firm can supply a vehicle. If the business supplies a vehicle without a driver, the firm is legally considered to be a lease firm, but if the business selects the driver as well as the vehicles, the firm is legally a taxi, limousine, or public livery operator.

Lease Firm

There are many types of leases--day leases, long-term leases, open-end or closed-end leases, with- or without-maintenance leases, with- or without-insurance leases, etc. The details of the lease make very little difference as long as the driver is not supplied at the same time as the vehicle. Except for tax purposes, there is essentially no difference in a long-term, open-end lease and a vehicle purchased with a loan from a financial institution. The following legal issues face leased vans:

1. Liability: The liability for the operations of the leased vehicle would normally be on the lessee and on the driver of the vehicle, not on the lessor. The lessor, like an automobile dealer, would be liable, however, if a defective vehicle were furnished. Thus, the group was asked to identify the individual who would assume full responsibility, not only for the passengers, but for all the damage to the vehicle itself.
2. Financial risk: Under a lease, the lessee is normally responsible for all financial risks by virtue of the contract (lease). The lessor, of course, would bear the financial risks if the lessee was unable to pay the lease charges, but the lessor would have a claim against the lessee for violation of lease. Thus, not only did the group have to put up the first and last month's lease payment, but also one or all members of the commuter group had to accept responsibility for all contractual lease payments.

   The popularity of vanpooling is creating a new form of leasing for vanpools, however. The Hertz Corporation offers a vanpool lease with a maximum lease commitment of three months with automatic monthly extensions. The Chrysler Corporation offers monthly leases. In essence, the lease firm accepts the risk of vanpool failure but feels that the probability of loss is very low because of the success rate for vanpools and the availability of new groups to take over the van even if a pool fails.
3. Restrictions on use of vehicles: Usually, limitations are placed on the amount of annual mileage that may be driven and any activity that would damage the vehicle or reduce the value of the vehicle at the end of the lease. These restrictions normally are to protect the lessor from financial loss where the salvage value at the end of the lease is fixed.
4. Taxes: Lessees are expected to pay full sales taxes, registration taxes, and fuel and other taxes. If the vehicle is leased by a business, the vehicle lease may be tax deductible if it is used to transport employees in a business operation. Unless the lease can be considered a business expense, it is not tax deductible by a private owner-driver like an interest payment in the financing of a van. Thus, a major distinction between a lease and the financing of the van through a bank is the ability of the taxpayer to deduct the interest to reduce taxable income.

Public Livery Firm

If the group or the firm desires the lessor to supply the driver, then the firm is no longer considered a lease firm but a public livery organization. Under this arrangement, the vehicle would be operated much as the transit authority or a taxi.

In this case the transportation would probably be considered to be for-hire transportation and the higher legal standard of care would apply, just as if the van were owned by the transportation authority. Full liability would belong to the firm.

The state regulatory bodies would, in all probability, retain control over the route, fares, entrance into the business, and the discontinuance of unprofitable routes. Thus, if a route needed to be changed due to one rider's moving and another's joining the pool, regulatory approval might be required, with proper notice and public hearings.

Under this arrangement, the firm would probably require a long-term contract in which the commuter group would pay the cost of the operation. If the group defaulted, the firm would bear the ultimate financial responsibility, unless the contract was enforced by a court. The firm would, however, be able to transport other groups like a taxi or airport limousine service if the regulatory body granted approval.

Usually, these vehicles are highly taxed, including not only sales taxes, registration fees, and all the other fees paid by private vehicles, but also special seat taxes, license fees, and fuel taxes charged to for-hire commercial carriers.

The state regulatory exemption for vanpooling in this instance would probably not be pertinent because this model would not fit within the framework of most existing ridesharing legislation. The vanpooling exemption generally assumes that the driver can only be selected by the employer; otherwise, the van is a private, driver-owned vanpool.

Employee-Provided Vehicle (Driver-Owned Vanpool)

After realizing that a lease program required the group or one of its members to take full financial responsibility anyway (the short-term Chrysler leases are an exception), the group decided to see whether one of their members should purchase a van or whether the group should consider incorporation.

Two important questions must be raised for privately owned vehicles: (a) Are shared-expense vanpools subject to regulation in that state? (b) Should the driver consider the vanpool operation to be a business? The first question was extremely important as late as 1978, but in many states either some version of vanpool deregulation has been passed or the state public service commission has decided not to enforce strict regulatory controls. Some states still regulate vanpools to varying degrees. If the vanpool is regulated, the vehicle will probably come under the law that applies to the for-hire commercial companies, since only for-hire commercial carriers are regulated by the public service commissions.

The second question is much more difficult: Is ridesharing considered to be a business? Legally, an activity is considered to be a business if

1. The primary reason for being involved in the activity is to earn income and
2. The activity is of continual duration (for example, if an individual sells one car per year, that is generally considered to be a casual venture, but if the individual sells 100 cars per year, that is generally considered to be the person's business or occupation; i.e., if it is occasional or casual, then it is not a business).

The importance of whether or not the van is considered to be a business is demonstrated by examining issues affecting employee-owned vanpools.

Financial Risk

The employee-owner would bear all financial risk. That is, the employee would have the responsibility of purchasing the vehicle, making payments on the vehicle, and obtaining enough passengers who pay their fair share of the cost of purchasing and operating the van.

In general, most private vanpool owners can obtain vehicle financing. Some financial institutions, such as Riggs National Bank, Bank of Virginia, and some credit unions, were providing 100 percent financing (prior to the financial crunch) based on the fact that the vans are not a personal expense, such as a car or a boat, but an income-generating investment, especially if there is some group that can help the driver find passengers to keep the vehicle filled.

Regulation

Under the evolving state ridesharing legislation there has normally been one or more legal tests of whether or not the pools are exempt from state public service commission regulation. These evolving legal tests are as follows:

1. The operation must be "not for profit." Although this is an easy concept, the question is what "profit" means. Can the nonprofit fare include, for example, gasoline, parking, insurance, license fees, depreciation, finance payments, maintenance cost, tires, depreciation on the office and garage at driver's residence, office expense, telephone, typewriter, business privilege tax, etc.? If the van is also for personal use, how should cost be divided between personal and commuter use? Should average, marginal, or total cost be used? If the operation is considered to be a business, then all costs should be allowed. If it is not a business, then the driver may be required to reduce costs by the driver's prorated share of expenses. For example, if nine persons, including the driver, were riding in the van, then the total cost would have to be reduced by one-ninth (the driver's share) in determining whether the operation were profitable.
2. The pool must not exceed a certain number of persons. In general, individual state provisions have ranged between 8 and 15 passengers. In many states, the exemption is based not on the number of passengers, but on the number of seats in the vehicle.
3. The trip is incidental to the trip purpose of the driver. Under this concept, the driver is going between the same origin and destination as the passengers. This exemption may include vehicles of any size; for example, in Missouri, any vehicle driven to work by a commuter going to work at the same location is exempt. The concept is that the driver is not making the trip primarily for income purposes and therefore the pool is not a business.

Liability

The liability for operating the vehicle is fully on the shoulders of the driver (who also owns the vehicle). In the event of an accident in which the driver is negligent, the fellow passengers look only to the owner-driver for recovery in case of injury.

Taxation

The revenue collected by the driver may or may not be taxable income, depending on varying interpretations of Revenue Ruling 55-555. This depends on whether the operation is considered to be a business. The Internal Revenue Service (IRS) holds that if it is not a business, but merely a sharing of expenses, then Ruling 55-555 would place all revenue and costs outside tax considerations. If, however, it is held to be a business, then detailed records must be kept and it appears that the vanpool driver would be eligible for all investment tax credits, depreciation, and other business deductions, such as those for an office in the home. If the driver-owner assumes that the Revenue Ruling 55-555 does not apply and later is informed by the IRS that it does apply, the driver may find that he or she has not kept adequate records to justify all costs. Therefore, the driver may find that he or she owes substantial taxes and penalties. On the other hand, if careful records are kept, the taxpayer could be eligible for a substantial refund due to the investment tax credit, depreciation, and the cost of the office in the home, for which the business may be eligible to deduct. The key limitation contained in Revenue Ruling 55-555 is as follows:

> However, this revenue ruling is not intended to apply to the situation where a particular car owner has developed his carpool arrangements to the extent that he can be said to have established a trade or business of transporting workers for hire from which a profit is derived.

At this time, the applicability of this revenue ruling and the position that the IRS will ultimately take are unclear. Until this ruling has been clarified, the driver/owner does not know whether the tax benefits of being a business will outweigh the additional cost of insurance that occurs if the van is classified as a business.

In addition, if the vanpool is considered to be a business, the van owner may be subject to all the standard taxes such as sales tax, registration fees, and fuel taxes plus business taxes, such as business privilege taxes. (A shared-expense vehicle has no income or sales tax, and other business taxes do not apply.) In addition, it may be illegal to operate a business or to park commercial vehicles in some residential areas because of zoning.

Restrictions on Use

Noncommuter use of the vehicle is restricted only if the noncommuter use is regulated. For example, if the owner attempts to take groups of Boy Scouts, senior citizens, or others and they share expenses for trips, in states where vanpool exemptions were limited to work trips or where more people ride than was authorized in the state vanpooling exemptions, these uses would be restricted. (If the state exempted vans of 10 passengers or less and 11 people are carried to the Boy Scout outing, then this shared-expense use would not be exempted.) Otherwise, the van owner may use the van anywhere he or she would operate a privately owned car.

Insurance

The driver would have to purchase a sufficient amount of insurance to protect against liability and also to afford passengers compensation if they are injured either by the driver or by a third party. Normally, this insurance is to be obtained through the owner/operator's private automotive insurance policy. If the pool is not considered to be a business, then the van would be insured under the driver/owner's private automobile policy just like a privately owned car. If the pool is considered to be a business, then it would be insured under the commercial automobile manual and frequently with a different insurance company.

In summary, if the employee provides his or her own vehicle, it must be decided whether the pool should be considered a business or nonbusiness activity. (The legal name of the latter is not clear because it is not a joint venture, it is not a partnership, it is not a business, it is not a family relationship, and it is not a charity, but at the same time it is not strictly a private affair.)

If the pooling arrangement is a "nonbusiness," then

1. No tax benefits or tax-break incentives would be available to the driver,
2. The taxability of the revenue as previously stated pursuant to the Revenue Ruling 55-555 is not clear,
3. The private automobile insurance policy would probably provide the required coverage if this activity is considered to be noncommercial, and
4. It is uncertain which records are necessary to prove that the activity is or is not a business for purposes of income taxation.

On the other hand, if this activity is a business, then the following characteristics apply:

1. The individual will receive tax benefits (the individual will be allowed to depreciate the vehicle, deduct expenses, including lease payments, and receive an investment tax credit). Other income tax questions are raised. For example, how does one calculate the tax? Does one allow full depreciation but not accelerated depreciation? Does one allow the accelerated investment tax credits? Is the individual allowed to have a deduction for an office in the home, for a telephone, for a typewriter, and for other bills? Must there be a profit to continue operating as a business? In other words, could a vanpool become a tax shelter? To what extent can the individual claim tax credits?
2. There will be a record-keeping requirement because the individual will be claiming this activity as a business and will need to support and verify all deductions.
3. It would be uncertain if this would be considered a for-hire activity, and it may ultimately be up to a court to determine whether or not this would constitute regulated transportation. In states that have exempted this kind of transportation from regulation, there would be no question, but in other states where either they have not passed any exempting legislation or the exemption passed was too narrow, this activity quite possibly would be regulated.
4. Since this is a business, the individual would be subject to any sales taxes, business privilege taxes, etc., that are required for businesses, together with penalties.
5. From the point of view of the insurance industry, when is this activity a business and when is it a nonbusiness? When is the private automobile policy to be used and when is the commercial automobile policy to be used? The commercial automobile insurance is usually more expensive.
6. How is "nonprofit" defined? Does the business remain nonprofit if income is earned, since nonprofit businesses may earn an income and for-profit businesses may have a loss?
7. If this is a business, what other regulations

such as zoning restrictions and business taxes would apply?

Incorporation

After considering the concentration of liability on the owner/operator, one of the pool members suggested that the group consider incorporation. If the 10 or 15 member commuters decided to incorporate, the law has still another treatment of the operation. Normally, corporations are created to conduct businesses and usually there is a profit motive; however, there are also such things as nonprofit corporations. The same questions raised above would be applicable. Besides those discussed above, additional legal considerations arise:

1. Liability for conducting the business or nonbusiness, whatever the case may be, would be placed on the corporation. Many people assume that by incorporating, individuals can escape all liability. This is not true. If the driver of the vehicle by his or her negligence injures someone, he or she may be named in the suit in addition to the corporation, especially if the corporation has insufficient assets to compensate those that are injured.
2. Since this is a corporation, the corporation would have to have commercial insurance and would not be eligible for the broader family automobile policy coverage.
3. Who assumes the financial risk in a corporation? Normally, banks will not lend to new corporations until they have built up sufficient assets. Banks normally require that there be individual cosigners on any loan made to a small corporation. If the owners of this business (or nonbusiness) cosign a note with the corporation, even though the corporation will be primarily liable in the event of a default, the individuals who cosigned will be secondarily liable, so they all must incur the financial risk.
4. Most states have special corporate taxes, such as state income, franchise, excise, and privilege taxes, that would be applicable.
5. The formalities of corporate ownership and control would have to be observed; i.e., minutes would have to be kept and by-laws and the charter would have to be kept in proper order.

WHAT ARE THE MAJOR PROBLEMS?

This review of various approaches to vanpooling and other ridesharing efforts illustrates the frustration to which ridesharing promoters have been subjected in involving employers, unions, transportation authorities, and individuals in ridesharing. The growth of ridesharing in spite of all these concerns bears testimony to the practicality and popularity of this approach to transportation. It also illustrates another important principle: Our legal system does not have a place for individuals who mutually cooperate to solve basic individual and societal transportation problems.

Law in general addresses several categories of activities:

1. Family or domestic or private activities between parent and child, husband and wife, etc., for which the law is established to protect;
2. Criminal activities, for which the law is established to prohibit certain types that would injure other persons; and
3. Administrative and revenue activities, for which government raises money and carries on the process of government.

Ridesharing does not fit into any of these categories, and when it is forced into commercial or business law, the legal barriers arise.

Traditional government activity, especially in the transportation field, has focused on three basic legal approaches, none of which applies to ridesharing:

1. In the regulation of transportation firms, the government first declared that the operation of commercial, for-hire transportation was a privilege, and thus the transportation firm could only supply for-hire transportation if given this privilege by the appropriate political body. A regulatory body (ICC, Civil Aeronautics Board, or local taxi board) was established to prescribe how the service should be provided. If the service was not provided in accordance with the decisions of the regulatory body, the regulatory body was given the authority to deny the firm the privilege of operating and thus of being in business.
2. The government would levy taxes on transportation vehicles, their fuel, and their owners to generate funds to purchase transportation improvements such as highways and street lighting.
3. The right of individuals to transport themselves when there is no commercial interest has generally only been limited by safety considerations.

Ridesharing is somewhat foreign to standard government operating methods. Ridesharing is a cooperative endeavor among individuals attempting to solve their own problems outside of normal government procedures. It does not conform to standard government procurement or contracting procedures. Government can only facilitate, encourage, or promote this largely cooperative activity, but it cannot effectively pay people to ride together. Public transportation advocates thus find themselves in a dilemma where the most popular form of commuter transportation does not have a legal identity. In the classic case, Southern California Commuter Bus Service, Inc. versus Zappitelli (Case 9797), before the Public Utilities Commission of the State of California, Mrs. Zappitelli decided to carpool by using her van so her neighbors could get to work without fighting the 1973-1974 gasoline lines. The California Public Service Commission promptly charged her for providing commercial transportation without going through the costly and time-consuming steps necessary to legally obtain that privilege (or operating authority). The publicity resulted in a change in the regulatory law.

RECOMMENDED LEGISLATIVE PHILOSOPHY

Since 1974, many states as well as the federal government have exempted certain types of vanpools from economic regulation by the various regulatory boards. These legislative efforts have primarily been directed toward removing regulatory or tax barriers and have emphasized that ridesharing is not traditional for-hire commercial carriage. It is now time to state legally that ridesharing is a specific goal of public policy with its own body of law. This new body of law should address the following subjects.

Solution to Public Need

Commuter ridesharing is a solution to an urgent public need. The full cooperation of employers, employees, and government is needed to meet the national objectives of energy conservation, traffic control, reduced highway congestion and maintenance, improved air-quality standards, reduced commuting cost, and other transportation-related objectives. It is not equitable nor in the public interest to place the full cost or the full liability for the commute trip on any one group, especially where the cooperation of that group is so crucial to the accomplishment of national objectives. Therefore, legislation needs to firmly establish that cooperative efforts between government, employers, and employees to facilitate ridesharing should not be construed to be a fringe benefit nor to expand the employer's or government's liability for accidents incurred during the commute trip. This legislative approach should apply even if the government or the employer makes low-interest loans available to commuter groups to purchase vehicles, leases vehicles to groups of commuters, or assists commuters in finding other ridesharers.

The key legal test should be the degree of control that the employer or government exerts over the operation of the ridesharing vehicle. If the employer controls the operation of the vehicle and pays the majority of the cost of the commute trip, as in the case of transporting migratory farm workers, then the employer should be fully liable for its operation as under existing laws. Likewise, if a government body such as a military base or transit authority controls the operation of the vehicle, then government should be liable as under existing law. On the other hand, if a group of commuters desire to start a vanpool and the employer offers to guarantee the loan obtained from the local credit union, or if the employer (or a governmental body such as a transit authority) leases a vehicle to a group of commuters who select their own driver, set their own schedules, and share their own expenses, including the cost of the loan or lease, then this facilitating type of ridesharing promotion and support should not make either government or the employer liable for accidents to the commuters.

An analogy would be the sale of U.S. savings bonds, which was held to be a public service. Thus the employer was not held liable if Series E interest rates were lower than certificates of deposit or treasury bills. Also, since the sale of savings bonds was considered to be a public service, it did not become a fringe-benefit issue where the employer was pressured to pay an ever larger share of the cost of the bond. Without these two conditions, it is doubtful that employers would have supported the sale of U.S. savings bonds through payroll deduction.

Liability

Commuter ridesharing is a cooperative solution to a mutual problem and the total financial responsibility for all accidents should not be concentrated on those who take the initiative to implement the cooperative activity on a nonprofit basis. Therefore, ridesharing should be legally defined as a cooperative activity in which each ridesharer retains the same legal protections from injury as he or she would have if not ridesharing but traveling in a privately owned or family-owned automobile. If another vehicle were at fault, the ridesharers would seek to recover damages from the vehicle that caused the accident. If the ridesharing vehicle were at fault, the ridesharers would recover for their individual injuries just as if they were driving the ridesharing vehicle. If they were driving the vehicle themselves, they would not be able to sue themselves, but they would look to alternative sources of reparations. Injury to individuals who are not ridesharing would be handled just as it is now. This approach would assure that no one would be disadvantaged financially by ridesharing. This approach avoids the concentration of risk where financial responsibility for all passenger injuries is now concentrated--on the driver or owner of the vehicle. The current concentration of liability not only discourages ridesharing but also requires that each vehicle involved in ridesharing increase its insurance limits to cover the maximum number of people who might ride. If five individuals who always drove alone decided to alternate driving, then each vehicle would have to increase insurance coverage to include the possibility that all five might be injured while ridesharing. Under the proposed legal philosophy, these five commuters would look to the same insurance (or other payment methods) as if they were driving alone and the same accident and injuries had occurred. Thus, there would be no increased risks or cost to anyone, including any insurance carrier, because of the ridesharing arrangement. In the unlikely case where the ridesharer had no insurance coverage of any kind, this exception could be covered by the insurance on vehicles in which they were riding through, perhaps, first-party medical pay insurance. The State of Michigan is approaching this when they place ridesharing vehicles under the "follow-the-family" type of no-fault insurance.

There are other legal precedents for such an approach to liability. When a person participates in casual or community athletic programs, the legal doctrine of assumption of risk is well established. Each player accepts the risk of injury to himself or herself and will not sue the other team members in case of an accident. If it were not for this principle, it would be very difficult to get people to play touch football or go on Boy Scout hikes or have the many volunteer recreational programs now available.

The sharing of risk for accidents would eliminate the major barrier to ridesharing in individually owned vehicles.

Suggested legislative language related to defining government and employer liability for ridesharing accidents appears below:

WHEREAS, it is recognized that employees and the nation as a whole benefit greatly when employees and government cooperate with employees to promote commuter ridesharing programs;

WHEREAS, it is in the best interest of the nation as a whole and individual employees in particular to encourage employer ridesharing programs;

WHEREAS, it is in the best interest of the nation and employees to clarify any barriers that would inhibit this cooperation.

NOW, THEREFORE BE IT RESOLVED AS FOLLOWS:

Employer's and Government's Role in Providing Vehicles for Ridesharing.

1. Employers and the government shall not be liable for injuries to passengers and other persons resulting from the operation or use of a motor vehicle not owned, leased, or contracted for by the employer or government in a ridesharing arrangement.

2. Employers and government shall not be liable for injuries to passengers and other persons because they provide ridesharing support activities, such as information, incentives, vehicle loans, or security for loans or leases, or otherwise encourage employees and commuters to participate in ridesharing arrangements.

Role of Transit Authority

The role of public bodies such as regional transit authorities (RTAs) needs to be redefined from that of owning, operating, and funding traditional public transportation service to the facilitation of all public transportation options. The role of the RTA should be shifted from an entrepreneurial one of preserving the bus company to a mission-oriented one of serving various public transportation needs. Until the RTA boards and executives recognize the difference between the entrepreneurial role of preserving specific transportation service and the public mission to solve a specific problem, it will be difficult to implement alternative solutions. To implement a mission-oriented approach, there is need to separate the rules, liability, funding, and guidelines that apply to the entrepreneurial operation of the traditional services and the promotion and procurement of alternative services. For example, if a transit authority finds it more cost effective to promote carpooling than to add additional buses into low-density suburbs, the carpool efforts should not extend the common-carrier liability standard, Section 13(c) labor protections, public hearings over route and fare changes, and noncompetitive requirements to cover all carpools that develop.

Tax Issues

The IRS should resolve the tax issues and decide whether ridesharing is a business. The goal of ridesharing is to accomplish public goals through the cooperative effort of individuals (employers, employees, public officials, administrators, neighbors, friends, schoolmates, and other groups) who voluntarily decide to ride together. By making some vans tax-deductible and others highly taxed and by being unable to define when a vanpool is a business and thus which laws are applicable, the tax mechanism is a strong force to artificially structure the form vanpools take.

Currently, discussions are under way to subsidize employers to assume a large legal responsibility for their employees' transportation to work or to support transit authorities to do something they are ill-equipped to do, whereas individuals who can easily do it are discouraged by the uncertainty of liability and tax issues.

Federal tax law should recognize the following points:

1. Ridesharing is a cooperative area of activity and not subject to the traditional business or personal accounting and tax principles.
2. Employer efforts to promote ridesharing are a public service activity and should not necessarily be limited to employees only. For example, the investment tax credit should apply regardless of whether the pools include nonemployees, because this restriction encourages the destruction of pools involving neighbors or spouses who may work for nearby employers.
3. Individual pools are cooperative efforts and should have well-defined accounting and tax procedures without reference to whether or not the driver considers it to be a business.

Federal and state legislatures should explicitly recognize that it is in the national interest for government to permit individual citizens to cooperatively resolve their own transportation problems at their own expense and that these solutions should not be restricted to promote government-subsidized solutions, such as mass transit, the National Railroad Passenger Corporation (Amtrak), rail commuter services, subsidized intercity bus runs, or employment programs for drivers under the Comprehensive Employment and Training Act.

SUMMARY

Government seldom faces such a logical, inexpensive, and acceptable solution to a major national problem. Unfortunately, both state and federal government must make major legal and policy changes if the full potential of the ridesharing solution is to be realized. This paper has attempted to illustrate how government has unintentionally inhibited ridesharing by first making it illegal and then, after it was legalized, by applying archaic, inappropriate legal structures that did not recognize its cooperative, public service orientation. Seldom has government been faced with such a productive, low-cost situation requiring such a redirection in regulatory, tax, liability, insurance, and funding philosophy.

Demand Analysis for Ridesharing: State-of-the-Art Review

LIDIA P. KOSTYNIUK

The methods that are currently used to estimate demand for ridesharing for the work trip are reviewed. These techniques are categorized by the basic approach used, and models within each category are described, reviewed, and summarized. The first category consists of those techniques developed from the perspective of the formation of ridesharing units and includes the assessment of areawide ridesharing potential by estimation of possible matches and the identification of characteristics of the population that shares rides. The second category includes the techniques that view ridesharing as an individual or household decision. These include utility maximization models and household travel decision simulations. The third category includes those models concerned with estimating changes in ridership by various modes, including ridesharing, that result from the implementation of high-vehicle-occupancy treatments. These models consider demand and supply effects to obtain equilibrium traffic flows.

Ridesharing, the transportation of persons in a motor vehicle where such transportation is incidental to the purpose of the driver, did not generate much interest on the part of transportation analysts prior to 1973-1974. Until then, traditional transportation demand methodology developed in the 1950s and 1960s did not directly concern itself with ridesharing, and the sharing of rides entered into the planning process only through the automobile occupancy model. The objective of the automobile occupancy model was to convert person trips into vehicle trips for the purpose of planning highway facilities. Although the possibility of affecting vehicle occupancy by deliberate public policy did occur to planners in the 1960s, it appeared at that time to be beyond the realm of practicality (1).

The energy crisis of 1974 and the subsequent concern with transportation system management (TSM) called for transportation-planning techniques, which included ridesharing specifically. Those responsible for contingency planning wanted to know how much of the urban travel could be diverted to ridesharing in times of emergency. Those responsible for TSM wanted to know the impacts of strategies to increase automobile occupancy. Employers and other agencies considering ridesharing programs wanted to know what results to expect from their promotional and organizational efforts. These needs led to the development of techniques for estimating demand for ridesharing and also generated basic research into the motivation for ridesharing behavior and its effects on the overall travel patterns. Thus, a growing body of knowledge is becoming available for ridesharing applications.

Ridesharing includes the arrangements of carpooling, vanpooling, and buspooling. The obvious difference among these is the type of vehicle used. Carpools use private automobiles and although privately owned vehicles are used in some vanpools and buspools, such vehicles are usually supplied by employers, third-party providers, or transit companies. The number of persons in each arrangement is obviously a function of the capacity of the vehicle. In all cases the routes followed by the vehicles are tailored to the convenience of the rider group and can be modified to reflect rider needs. Collection and distribution arrangements also vary; a common collection point is popular for large groups. Payment arrangements range from no monetary exchange in shared driving arrangements to payments by pool members to the driver and, in some employer-organized vanpools, through payroll deduction. Since most of the ridesharing promotional efforts have been concentrated to encourage the solo driver to change to ridesharing during the work trip, most research on ridesharing behavior and forecasting techniques has also been concerned with the work trip.

Ridesharing, and therefore demand estimation for ridesharing, can be considered from several approaches. One approach is consideration of the group who will travel together in a common vehicle. Of interest here is the process of formation of the group as well as the conditions for its existence as a unit. Another way of viewing ridesharing is in the context of household travel decisionmaking and under what circumstances ridesharing is an option for households. Still another way to look at ridesharing is from its influences on the movement of traffic in an urban area, especially on the capacity and level of service of traffic corridors.

Although this categorization of approaches is not unique, most ridesharing demand estimation methods can be broadly classified under one of these three approaches. This paper reviews the methods currently used to estimate demand for ridesharing. The techniques are categorized by the basic approach used, and the models within each category are described and reviewed.

RIDESHARING UNIT FORMATION

The first approach is based on the ridesharing unit formation process and stems from the concern of identifying and matching people into such units. A set of conditions necessary for the formation of a ridesharing unit requires that

1. The origins and destinations of the trips of the potential pool members be spaced in such a way that the travel between them is acceptable to all the potential pool members,
2. The time interval in which the trip occurs be acceptable to all potential members of the pool,
3. The potential ridesharers be aware of each other,
4. There be sufficient incentive (economic, social, etc.) to travel together, and
5. The group be adequately compatible so that the ridesharing arrangement will be maintained over a period of time.

Consideration of ridesharing group formation leads to the issues of the target population, the matching process, and the characteristics of the resulting ridesharing units. The types of ridesharing estimation techniques that come from the consideration of the formation process are the ridesharing-potential models and the technique of identifying characteristics of users and potential users and applying these in an expansion process to the population under consideration.

Models of Ridesharing Potential

The objective of these models is to estimate the ridesharing potential of an area. There are two categories of these models--the maximum-potential models and the economic-incentive-potential models. The objective of the maximum-potential model is to give a practical upper limit of the ridesharing potential of an area. Results from such a model would be used to plan for emergencies and crises such as energy shortages or transit strikes in large cities and can also be used as a reference for evaluation of ridesharing programs. The economic-incentive-potential models, on the other hand, give estimates that could be used for planning long-term ridesharing programs.

An early maximum-potential model was developed by Kendall (2) and was used to estimate the carpooling potential of the eastern Massachusetts metropolitan area.

The model matched origins and destinations in zones the boundaries of which had been established a priori. An assumed maximum allowable time interval in terms of inconvenience to commuters was also set a priori. Thus, all workers with common origins and destinations who depart the zones within the same time interval were candidates for carpooling. The need for the car during the day as well as the consideration that a portion of the population does not travel to work during the peak periods were included as adjustment factors in the model. There was no consideration of economic incentives, user preferences, or the compatibility of the ridesharers.

By using trip tables developed from a 1963 home interview survey and matching time intervals of 30 min and average origin and destination sectors of 1 mile each, the ridesharing potential was estimated to be approximately 60 percent of the morning commuter trips.

Another type of maximum-potential estimation was carried out by Lee and Glover (3) by using 1976 Michigan driver data. It was assumed that the maximum potential for ridesharing was reached when the automobile occupancy for all trips more than 10 min long commencing between 6:00-9:00 a.m. and 3:00-7:00 p.m. was at least three persons. Considering only trips in the Standard Metropolitan Statistical Areas in Michigan, they calculated that this level of ridesharing would result in an annual 10 percent reduction in gasoline consumption. Although Lee and Glover did not estimate ridesharing potential directly, Cheslow, in a comparison of the two potential models (4), reports that when their analysis is carried further, it yields an estimate very similar to that of Kendall.

The automobile occupancy of at least three persons per car seems arbitrary and Cheslow suggests that using the automobile occupancy rates of nonwork group travel in maximum-potential estimates would reflect capacity and reasonable physical comfort inside vehicles. The average size of groups for social and recreational travel, the most frequent type of group travel, is 2.8 persons/car. Since it includes children in many cases, Cheslow suggests that applying the average group occupancy of other nonwork travel of 2.55 persons/car to commuter work trips would give an estimate of maximum potential for ridesharing for the work trip.

When the Kendall and the Lee and Glover models are compared against the general necessary conditions for ridesharing unit formation, it can be seen that the first two conditions, concerned with spatial locations of origins and destinations and with the common time interval, are satisfied. It can also be assumed that in emergencies there is an incentive to travel together, and although compatibility of the members of the ridesharing units is not addressed, it is implicitly assumed that people accept inconveniences during such times.

The consideration of how far people are willing to deviate from their routes in order to rideshare, in terms of their valuation of time, is the basis of another class of models of ridesharing potential. Such maximum deviations are applied to computer or manual matching programs and used for defining areas where ridesharing efforts are expected to be successful. The basic assumption here is that potential pooling trips are only those trips with common destinations that are adequately clustered, so that the cost of pooling, considering the users' value of time, is less than the cost of driving alone.

Berry (5) developed such an economic-incentive model for carpooling potential by assuming that a carpool unit will form if, for all the members of a pool, the marginal savings exceed the marginal costs of pooling for the work trip. The marginal costs are a function of the value of time for each member of the pool as well as of the out-of-pocket travel expenses. He derived the maximum economic circuity--the difference in length of the one-way trip (including the collection of members of the pool) and the average length of the trip for each of the members driving alone--as a function of costs and travel time. This maximum circuity increases as line-haul distance increases, as the value of time decreases, and as the costs associated with commuting (such as parking) increase.

Berry proposed that commuter response to various ridesharing incentive strategies be assessed by calculating the changes these have on circuity and weighing these changes by the proportion of commuter population in each value-of-time category.

Johnson (6) developed a vanpool-planning model in which the costs of travel, including time and the adequate clustering of origins and destinations, were considered. She derived a maximum deviation of pool collection to line-haul distance, which varies with speed, vehicle occupancy, and the value of time.

Johnson calculated the regional potential for the van share mode by using a computer algorithm that searches an origin-destination matrix for trips of more than 10 miles to zones with large employers. She assumes that only half of the commuters eligible to vanpool will do so and that a minimum van occupancy for vanpool formation is 10 people. Thus, 20 such trips must be clustered in a service area for one potential vanpool.

Soot and others (7) further developed these concepts into a planning tool known as the Service Area Identification Method (SAIM), which can be used to calculate the areawide demand for ridesharing. Aggregate origin-destination data are used in a simple algorithm that compares the travel costs and travel times of each of the trips by carpool or vanpool with travel costs and travel times of driving alone. The objective of SAIM is to identify those trip patterns that would be best served by each of these modes. The output of SAIM gives maps of the service areas for each mode, summary tables of regional information on number of users, trip lengths, etc., and zone-by-zone listings for both origin and destination of total trips and number of trips that can be considered to potentially use the mode considered.

The potential models with economic incentives differ from the maximum-potential models in that they are intended for more than just contingency planning and are designed to explore ridesharing potential under different conditions that affect the cost and travel time of the work trip. The SAIM model is intended as a complete planning tool for ridesharing. Examining this model for the general necessary conditions for formation of a ridesharing unit shows that the model addresses the spatial requirements, i.e., the adequate clustering of trip ends, and also provides a motive for ridesharing based strictly on costs and value of travel time. The compatibility of the poolers is not addressed. The model is, however, useful for identifying areas of ridesharing potential where ridesharing matching and promotional programs could be attempted.

Identification of Ridesharers

The existence and knowledge of a set of characteristics of ridesharers and potential ridesharers would be extremely useful in identifying incentives for ridesharing and in organizing and coordinating ridesharing programs. The knowledge of the distribution of the characteristics of potential ridesharers and the levels of incentives at which they respond could be an estimation technique in itself or could be used for market-segment identification for other estimation procedures.

Since most ridesharing programs publish statistical summaries that include information about the participants, attempts have been made to find significant differences between ridesharers and solo drivers from this information (8-15). The search has been directed toward sociodemographic, locational, attitudinal, and employment variables.

Attempts to identify a simple set of sociodemographic characteristics of ridesharers have generally been unsuccessful. Income does not appear to be a discriminating factor. Table 1 shows some of the results of sociodemographic comparison of ridesharers and solo drivers from several studies. No clear-cut differences in sociodemographic characteristics are immediately obvious. There is agreement in the literature that any existing relationships between demographic and work-trip ridesharing behavior are very weak.

Locational differences between ridesharers and solo drivers have been found to be significant in a number of studies. There is general agreement (8,9,11,16,17) that those who rideshare to work tend to have longer commuting times and distances than the rest of the population. This is supported by an investigation of the interaction of locational and demographic factors carried out at the New York State Department of Transportation (NYSDOT) (18) in which it was found that the best discriminator between ridesharers and solo drivers was the distance to work and travel time. Household size and licensed drivers per household were the only demo-

Table 1. Sociodemographic characteristics of ridesharers.

Source	Year Data Collected	Place	Sample	Sociodemographic Characteristics: Age	Income	Automobile Availability	Sex	Workers per Household	Marital Status	Occupation	Household Size	Licensed Drivers per Household	Salary Level
Voorhees (16)	1972	Los Angeles, CA	1896 freeway drivers	Younger	Slightly lower	Low							
Kendall (2)	1973-1974	United States	2084 automobile commuters	18-24	Lower	Low	Female						
Heaton (8)	1974	Boston, MA	4293 participants and 6288 nonparticipants in commuter computer program	Higher			Male			Professional managearial			
Davis (12)	1975	Knoxville, TN	Commuters to high employment areas			Yes			Married				
Peat, Marwick, Mitchell, and Co. and Market Facts (27)	1975	Chicago, IL; Pittsburgh, PA; Sacramento, CA	100 in each of 3 concentric rings in each city		No difference		Male						
Horowitz and Sheth (9)	1975	Chicago, IL	822 commuters to 43 large firms	Older	No difference	No difference	No difference		Married	No difference	Large		
Margolin and Misch (11)	1977	Washington, DC	20 panels and survey of 500 commuters	30+		No difference	Male	2+			No difference		
Dobson and Tischer (14)	1977	Los Angeles, CA	889 central-business-district commuters		Lower			2+					
Brunso, Kocis, and Ugolik (19)	1979	Albany, NY	901 commuters	No difference			No difference				Minor interactive effect	Minor interactive effect	No difference
Cambridge Systematics, Inc. (15)	1980	Minneapolis, MN	Choice-based sample of 200 commuters to 2 sites	No difference	No difference	No difference	-[a]			Production worker			

[a]One site in this study showed a higher percentage of female commuters carpooling than male commuters.

graphic variables that entered interactively into the discrimination, but only in a minor way. It is interesting to note that in a recent similar investigation of nonwork ridesharing (19), these same demographic characteristics were a much stronger discriminator between ridesharers and nonridesharers than they were for the work trip.

Another factor considered to be related to ridesharing behavior is the individual's employment characteristics. A widespread method of estimating ridesharing potential at an employment site is to multiply the number of employees in firms over a certain size by a factor transferred from a ridesharing program at a similar site.

Suhrbier and Wagner (20) report that a literature review of vanpooling contained estimates of the vanpool modal share that ranged from 25 to 50 percent of those employees eligible to vanpool and that, within individual companies, vanpool shares of about 10 percent of all employees are common. Carpooling shares are often estimated to be about 30 percent.

The problem with this transfer procedure is that the ridesharing programs, especially vanpool programs, differ greatly from one area to another. Thus, care must be taken when using this method for predicting demand.

In attempts to get at differences between ridesharers and solo drivers, several studies have sought to identify attitudinal and perceptual differences between the two groups with respect to ridesharing. Horowitz and Sheth (9), in a psychosocial analysis of ridesharers, identified the primary difference between the ridesharers and solo drivers as their perception of the time convenience, reliability, comfort, and saving of travel time. The Margolin and Misch investigation into the profiles of carpooling perceptions (11) of the two groups shows that the greatest differences were time-related (risk of being late, arriving home when expected, travel and wait time), comfort (crowding), and convenience (difficulty of making arrangements and space for packages).

In Heaton's study (8), the features of carpooling that carpoolers reported as being most appealing were cost savings, alleviation of congestion and pollution, and relief from driving. The features least liked by the carpoolers were reduced independence and mobility. Difficulties of adhering to schedules, other people's driving habits, inconvenience, responsibility to others, and increased travel time were of secondary importance. Reasons given by nonpoolers for not pooling were the need for a car at work, irregular working hours, and reduced mobility and independence.

A semantic differential analysis of attitudes of poolers and nonpoolers (16) showed that poolers liked to drive with others, whereas solo drivers did not, and poolers perceived a real cost savings whereas nonpoolers felt that the amount of savings was not worthwhile. Another difference was in reliance on others. Poolers were not averse to relying on others or having others depend on them, whereas nonpoolers disliked both options. It was concluded that the reasons given for not pooling are in fact excuses and that the real reasons involved personal independence, privacy, and freedom from others.

Social interaction emerged as the primary consideration in decisions to share rides in the Margolin and Misch study of ridesharing behavior (11). Distrust of computer matching was expressed by insistance on meeting people before arranging a carpool. Carpooling with strangers was ruled out by 39 percent of their sample. Women more than men and white- and blue-collar workers more than members of the managerial-executive-professional group were concerned about ridesharing with strangers. This finding is also reported by Levin and Gray (21), who in an analysis of interpersonal factors found that acquaintance was an important factor in carpooling and that the desirability of carpooling for an individual decreased as the number of nonacquaintances in the pool increased.

Status, a sensitive issue in our culture, also emerged as a consideration in the social interaction (11). It was found that, in general, people are wary of carpooling with others somewhat different from themselves. There was concern about intrapool behavior, i.e., talking, eating, and smoking. Since there are no established rules of etiquette or codes of behavior for ridesharing, rules of ridesharing (even rulemaking itself) were a source of anxiety. Margolin and Misch point out that smoking was an especially "hot" issue and that, although it was a legitimate issue in itself, it seemed to become a surrogate for other sources of dissatisfaction.

To date, the search for a set of identifying characteristics of ridesharers and potential ridesharers has not yielded a simple set. The only common characteristic of ridesharers across the studies reviewed is a long distance to work. However, there is evidence from these studies that the set of characteristics that defines ridesharer profiles consists of interactions of demographic, locational, and employment characteristics. Furthermore, it is reasonable to expect that these interactions vary across different segments of the population as well as with the incentives offered for ridesharing.

No study to date has systematically explored the carpool or vanpool as a unit of behavior and examined the similarities and differences of the characteristics of the individual members of pools.

DISAGGREGATE TRAVEL CHOICE

The second category of ridesharing estimation techniques is based on the disaggregate approach, which considers the choice to rideshare in the context of household travel behavior. Included in this are model sequences based on the assumptions of utility-maximization methods based on simulations of household activity and travel behavior.

Methods Based on Utility Maximization

The methodology that has had widespread influence on the estimation of ridesharing impacts was developed by Cambridge Systematics, Inc. (CSI) in a series of projects for the Federal Energy Administration and the U.S. Department of Transportation (22-25). It links together several models of household transportation choices to predict automobile ownership, work-trip mode choice, and nonwork travel (frequency, destination, and mode). Aggregated, it provides information for estimating changes in demand for travel under various TSM strategies as well as in energy use.

It has been adapted to be compatible with the Urban Mass Transportation Administration (UMTA) Urban Transportation Planning System, a set of computer programs in widespread use by metropolitan planning organizations for highway and transit network supply and equilibrium analysis, and has also been adapted for manual sketch planning (26).

The model sequence for a single household includes automobile ownership models for households with at least one worker and with no workers and work mode-choice models with a possible choice among three modes--driving alone, sharing a ride, and using transit. Since some of the level-of-service variables in this model depend on the number of people in the shared-ride arrangement, a separate submodel determines the size of carpool the person would be in if he or she shared a ride to work.

The household nonwork travel is modeled by trip-generation and joint-destination and mode-choice (automobile and transit) models for social and recreational trips and other nonwork home-based trips. The structure of the mode-choice model is logit with a linear additive utility function with level-of-service, locational, and socioeconomic variables.

Since carpools of various sizes cannot be treated as separate alternatives without violating a basic assumption of the logit model, a carpool-size submodel precedes the mode-choice model in the model sequence. Thus, the model predicts the size of a carpool that the individual would join, assuming that the individual would choose to rideshare, and the level-of-service variables based on carpool size are generated for the individual's ridesharing alternatives. The carpool-size submodel is structured with a linear specification and was calibrated by standard linear-regression techniques. The CSI set of models treats the vanpooling option by introducing it as a new mode only in circumstances where it was available to a worker (by having that information in a data set or by making assumptions about employer sizes in destination zones) and if the work journey was over some minimum trip length.

The household results are aggregated to give areawide estimates by using a random-sample enumeration method. The joint distribution of independent variables is represented by an appropriate random subsample of households from the original home interview survey. The choice probabilities are forecast for each sampled household and expanded to the entire population. Advantages of this method are that no assumptions on the distribution of the independent variables are required and impacts of policies aimed at particular identifiable groups can be estimated by using larger appropriately weighted samples from such groups. Furthermore, as more knowledge is gained about the identification of market segments of carpoolers, it could readily be applied in this aggregation procedure.

Another model for ridesharing based on utility theory developed by Peat, Marwick, Mitchell, and Company (PMM) and Market Facts, Inc. (27), used a trade-off approach in assessing the multiattribute utility functions of a set of individuals for various modes to work. Trade-off analysis is a type of conjoint measurement that attempts to answer the question of which combinations of circumstances are preferred to other circumstances by a set of subjects. A set of attributes, preselected by the researchers to represent what the researchers perceived to be relevant to the choice, were the mode used (e.g., driving alone in a car, driving with passengers in a car, being driven by another in a car, riding public transportation); travel costs (including gasoline and tolls or transit fare, as appropriate); parking cost; extra time (e.g., the time spent walking, waiting for others or for public transportation pickup, or dropping off others); riding time (e.g., the line-haul time); the number of people in the vehicle; the ease of finding transportation during the day for personal business; and the supply of gasoline available for consumption.

A special survey instrument was then designed to provide basic data for the trade-off model and to supply the parameters and base condition values necessary for simulating various carpool strategies. The survey also elicited information on trip characteristics and socioeconomic and attitudinal data. The subjects to which this survey was administered were from three urban areas (Chicago, Pittsburgh, and Sacramento), stratified by location from three concentric rings about the central business district (CBD) (100 for each ring in each city), and selected for their socioeconomic status.

The model yields a utility function for each subject that can be evaluated for each alternative for various levels of the attributes as determined by carpooling incentives. The aggregate modal split was estimated from the proportionality of the calculated utilities for the modes of each individual. Since each subject was taken to represent a group of people similar with respect to sociodemographic and locational characteristics, the proportionalities were used to estimate the aggregate shares.

This demand-estimation procedure uses a very powerful tool from the field of decision theory and has made progress in the development of the type of demand model that is policy-sensitive and can handle modes such as ridesharing. The study concludes with observations on methodology with the recognition that it did not incorporate the "soft" variables such as comfort and convenience and reliability. Nor did it include any social-interaction variables that are being identified by recent work (11) as being important.

Microsimulation

A microsimulation model sequence that uses the logit specification was developed by Bonsall (28) for the prediction of ridesharing. This computer model generates a set of commuters and simulates their decision process with respect to ridesharing. The sample of commuters is generated by a process designed to replicate the socioeconomic and locational characteristics of the population under consideration; it maintains the intercharacteristic probabilities revealed in a household survey and within a control total derived from published census material. The model allows applications for up to seven types of ridesharing schemes, which range from carpooling to giving or receiving rides in the morning or in the evening or both. A filtering process is used to establish a feasible set of alternatives for each actor.

A series of binary logit models is calibrated and used to calculate the probability that each commuter will join a carpooling arrangement. This is converted to a likelihood of submitting an application, checked against a threshold of interest, and determines whether the commuter submits an application. A submodel simulates the processing of applications and matches ridesharing interests, times, and locations.

The model further simulates the decision of each person; it considers a list of potential traveling companions supplied by the organizers. The expected utility to a given person of a given arrangement is assumed to be a function of the personal characteristics of that person, of personal characteristics of the proposed partners in the arrangement, and of the operational consequences of the arrangement such as delays and diversions. The parameters are calibrated on a series of regression equations by using data from a field survey.

The model user defines the scale and location of the ridesharing scheme to be tested by defining a target population in terms of their residential location, work location, or some combination of the two. The user also specifies a threshold of interest, which may be taken to represent the intensity of an advertising campaign conducted among the target population.

The model maximizes this utility for each individual. For any arrangement that has positive net expected utilities, the one with the maximum net expected utility to the applicant is selected, and a match is designated as successful. Since the decision to match was based on expected utility, which in reality may be revised, the next submodel simulates the survival of the match.

The last feature of the model is the output of system performance indicators. These include the summary statistics, information on work-journey public transit patronage lost, and information on private vehicle use changes in automobile occupancy.

Bonsall and Kirby (29) used this model to predict ridesharing for the city of Leeds under various scenarios and to examine policy implications on the transportation network. This model is offered as a predictive tool for estimating areawide ridesharing and employer-based ridesharing under various conditions. It differs from the other utility-maximizing models of ridesharing in that the interpersonal nature of ridesharing is considered. The model not only captures the necessary commonality of origins, destinations, and time intervals and considers the levels of service for carpooling, but also addresses the compatibility of the commuters by simulating the match survival. Some of the insight gained by the various behavioral investigations into who rideshares and why and when is being applied to the ridesharing estimation process. Since the procedure is a simulation, i.e., one observation of an experiment, trustworthy results can only be obtained from many repetitions.

Household Activity Simulation

Interaction simulation games, a recent development in transportation planning, have been applied to ridesharing. These simulation games chart through time and space the activities and travel decisions of households. By using boards that represent time and space, an analyst asks members of a household to arrange their activities and travel and to rearrange them for various scenarios. The model simulates different situations but, unlike the microsimulation model, uses the actual decisionmakers as actors in the decision process. Thus, the method does not seek to model the decision process itself but observes reactions in a simulated environment.

This process yields much insight into the adaptations in activities, scheduling, and travel made by households faced with changes in the transport environment. It is computationally cumbersome and thus somewhat restrictive as a prediction tool; however, it is extremely useful in obtaining behavioral insight that could be useful in the prediction procedures.

The Response to Energy and Activity Constraints on Travel (REACT) (30) game has been developed by NYSDOT's Planning Unit and is currently being further developed as a planning tool. The initial application of REACT explored the responses of a small sample of households to various policies intended to reduce automobile fuel consumption. Policies tested were a 20 percent reduction in travel on weekdays, on weekends (a possible result of gasoline rationing), and a no-drive day on weekdays and on weekends. Preliminary results indicated that two-car households cut discretionary travel in response to the no-drive day policy. One-car households, however, carpooled and shifted schedules and destinations to adjust to both policies.

REACT and other such interactive games cannot be used as planning tools alone. However, they can identify direct and indirect public responses for assessment of policies with which there has been no previous experience. They provide first-cut analyses for many types of policies and can be used with other planning tools to estimate travel changes, including ridesharing.

TRAFFIC-EQUILIBRIUM MODELS

Another perspective from which ridesharing has been considered is that of traffic flow equilibrium. Encouragement of ridesharing by high-occupancy-vehicle (HOV) strategies such as priority ramps and exclusive lanes on congested facilities has a significant effect on the levels of service of all modes that use these facilities. Consideration of such strategies involves the assessment of their effects on traffic flow, including travel time and congestion, and involves the merging of demand relationships with those of supply or service.

A review of modal-shift models for HOV priority strategies (31) has identified several models that are capable of treating ridesharing in terms of equilibrium in traffic corridors. These models are the pivot-point logit model (CSI) (24), the economic-simulation model for priority lanes on urban radial freeways (32), the planning model for transportation corridors (33), the FREQ6PL freeway priority lane simulation model (34), the TRANSYT6C (35), and the JHK/Shirley Highway carpool mode-shift model (36,37).

The CSI model discussed previously can be used in the assessment of HOV strategies in traffic corridors. Application of the model requires the user to determine the distinct user groups that will be affected by the change. The changes in the level-of-service measures such as in-vehicle and out-of-vehicle times and out-of-pocket costs must be specified for each group. The incremental-logit model is then used to predict changes from the existing travel behavior. The predicted volumes are used to obtain new travel times, which are compared with those from the first estimate. If necessary, additional iterations can be made to reach equilibrium. The merit of the CSI model in this application is its extremely low computational requirements. It is also applicable to a large set of HOV strategies.

The economic simulation model for priority lanes on urban radial expressways combines the conventional logit demand model with a simple traffic-flow model. The demand model includes level-of-service variables such as transfers, in-vehicle and out-of-vehicle waiting and walking times, and travel cost and socioeconomic variables such as income, age, number of children, and length of residence in the neighborhood. The modes considered are car (with one or two occupants), carpool (three or more occupants), bus with walk access, and bus with car access. The travel speeds are obtained by a deterministic queuing model of traffic flow and the demand-and-supply models are iterated to equilibrium.

The planning model for transportation corridors also uses a logit demand model with level-of-service and socioeconomic variables. In this case, data for a representative sample of households in the study area are used to calculate modal choices for driving alone, ridesharing local bus, and express bus and/or rapid transit with various access modes. The choices with various access modes are carefully defined to avoid possible violations of assumptions of the logit model. The change in the level of service for both the access and line-haul portions of the trip is determined by supply-side relationships and a simultaneous solution to the demand-and-supply equations determines the equilibrium modal volumes.

The JHK/Shirley Highway model is based on the assumption that current carpools will choose the fastest path and that modal shifts will occur as the relative travel times between carpools and other modes change for any origin-destination combination. Modes considered are bus, single-occupant automobile, two-occupant automobile, three-occupant automobile, and carpool, which is defined as an automobile with four or more occupants. Diversion curves developed from empirical findings about modal shifts from the Shirley Highway demonstration project are used in this approach. The method consists of defining an origin-destination zonal system and a coarse network for the corridor of interest, identifying minimum time paths for every origin-destination pair, and obtaining average times and speeds for each link for the base and forecast period. The modal shares for each zonal pair before implementation of the HOV strategy are also required. The diversion factors from the Shirley Highway modal shifts are used to obtain changes to carpool modal shares. This method has no supply-side feedback. Its main merit is that it uses information from an actual observation of shifts to ridesharing.

Computerized traffic-simulation models such as FREQ and TRANSYT have also been used to assess the impacts of HOV strategies. These models, which have undergone several rounds of refinement at the University of California at Berkeley, can be used to assess demand shifts and travel-flow characteristics resulting from implementation of HOV strategies on expressways and arterial streets at the micro level. The modal shifts between automobiles and ridesharing and automobiles and bus are obtained by using demand relationships from a previously calibrated logit model, and the differences in travel time by various modes are calculated by a detailed supply-side algorithm. The demand shifts, however, are sensitive only to in-vehicle travel time. No access time changes are considered.

Use of aggregate before-and-after data coupled with the simultaneous consideration of demand and supply is the important feature of a technique developed by Charles River Associates (CRA) (38) to predict travel-volume changes in urban corridors resulting from implementing HOV priority strategies. This method, intended to be used as a first-cut estimate, does not need origin-destination data or the socioeconomic characteristics of the area. Supply relationships between travel time and travel volume were obtained from speed-volume relationships for various facilities from the Highway Capacity Manual. Traffic volumes were measured in 12 corridors before and after implementation of HOV treatments to assess the sensitivity of travelers to levels of service for various modes and to estimate elasticities and cross-elasticities for various modes.

The basic underlying assumption in models of this third category is that commuters respond to changes in transportation level of service. There is no concern for the matching of commuters into workable ridesharing units. With the exception of the JHK/Shirley Highway model and the CRA models, the demand model specification is a multinominal logit with level-of-service and, in most cases, socioeconomic variables, and the main difference among the models is in the treatment of the supply side and equilibrium. The treatment of demand in the traffic-simulation models is extremely simple and demand is assumed to be sensitive only to changes in the in-vehicle travel time. The JHK/Shirley Highway model and the CRA model use information from observed modal shifts to ridesharing after the implementation of HOV strategies.

SUMMARY

The knowledge about ridesharing has increased significantly since 1973-1974 and the national recognition of its possible benefits. Estimation techniques have also progressed from near nonexistence to the wide variety described in this report. The following tables present an overview and summary of those techniques. The estimation techniques vary not only by the purpose for which they are intended, but also by their degree of readiness for application. Some are offered as complete planning tools;

others can only provide a basis from which a planner can make judgments and others are starting points for more research.

Table 2 summarizes the models that can be considered complete methodologies. These include Kendall's maximum-potential model, SAIM, the CSI model, Bonsall's microsimulation, the set of traffic-equilibrium models, and the PMM and Market Facts trade-off model.

Table 3 summarizes the methods that, although not complete ridesharing estimation methodologies, have been used or have been proposed to estimate ridesharing. These methods include those characterized by the transfer of information from a known situa-

Table 2. Summary of ridesharing estimation methodologies.

Model	Ridesharing Application	Basic Approach	Model Type	Ref.	Past Application	Data Required	Computational Requirement	Merits	Limitations
Maximum potential	Contingency planning	Formation of ridesharing unit	Matching origins, destinations, and time	Kendall (2)	Tested with data from Boston, MA	O-D trip tables for automobile home-based work trips	Computer required	Benchmark for evaluation of ridesharing programs	Does not consider user preferences, compatibility of group, enroute matching or off-peak travel
Service-area identification	Identifies areas of ridesharing potential	Formation of ridesharing unit	Matching origins, destinations, and time	Soot and others (7)	Tested with data from Chicago, IL	O-D information	Computer required	Considers economic incentives; identifies travel patterns that can be served by ridesharing	Does not consider user preferences or compatibility of group; vanpool and carpool service areas estimated separately
CSI	Areawide ridesharing demand; demand at employment sites; modal shifts from HOV strategies	Household decision, equilibrium	Demand—logit; carpool size—regression; equilibrium—iteration	CSI (22)	Tested with data from Washington, San Francisco, Minneapolis	Socioeconomic, transportation LOS information, need base modal shares for manual method	Manual recalibration requires computer	Well documented; minimal data requirements for manual method; considers effects on other trip purposes	Does not consider user preferences or compatibility of group
JHK/Shirley Highway carpool modal shift	Estimates modal shifts from HOV treatments	Traffic equilibrium	Diversion curves	JHK (36)	Applied to data from Shirley Highway and Metro K line and I-66 corridor in northern Virginia	Specification of transportation analysis zones, routes, and number of work trips for all O-D pairs, travel times, and speeds	Manual	Based on observed modal shifts to carpools	No further interaction with supply
PMM and Market Facts trade-off	Estimates areawide ridesharing demand	Household decision	Trade-off	PMM (27)	Applied to data from Chicago, Pittsburgh, and Sacramento	Conjoint measurement data about modes used, time, cost, automobile occupancy, socioeconomic data, existing modal shares	Computer required	Gives much information about commuters' preferences by socioeconomic groups and location in city	Does not consider comfort, convenience, reliability; long, tedious method
Economic simulation for priority lane on urban expressway	Estimates modal shifts from HOV treatments	Traffic equilibrium	Demand—logit; supply—LOS function of V/C; equilibrium—iteration	Small (32)	No application in actual environment	Socioeconomic, LOS information at household level	Computer required	Workable equilibration process	Experienced analyst required; does not consider user preferences
University of California, Berkeley, traffic simulation	Estimates modal shifts from HOV treatments	Traffic equilibrium	Traffic flow microsimulation demand from nomograph derived from multinomial logit	Cilliers, May, and Cooper (34)	Case studies on Santa Monica Freeway and Wilshire Boulevard	Detailed network information, travel time by modes, signals	Computer required	Gives microeffects on traffic corridors	Demand sensitive only to changes in in-vehicle travel time
CRA-HOV travel-volume change	Estimates travel-volume changes from HOV treatments for sketch planning	Traffic equilibrium	Demand—incremental product and exponential; supply—volume and delay relationship; equilibrium—simultaneous equations	CRA (38)	Currently being tested	Existing modal volumes and LOS characteristics	Manual	Does not need socioeconomic data; calibrated on observed changes in travel volumes	Provides only first-cut estimates
Car-sharing microsimulation	Areawide demand; demand at employment site	Household decision	Microsimulation with logit demand	Bonsall (28)	Applied to data from Leeds, England	Household travel survey, socioeconomic, LOS data, census data	Computer required	Considers compatibility of group	Extensive data requirements
Planning for transportation corridors	Estimates modal shifts from HOV treatments	Traffic equilibrium	Demand—logit; supply—bottleneck method; equilibrium—simultaneous solution	Talvitie (33)	Prediction of HOV lane in I-580 corridor, San Francisco	Socioeconomic, LOS information at household level, free-flow speeds, bottleneck capacities	Computer required	Workable equilibration procedure; access and line-haul mode choices considered separately	Modal shares of representative households may not represent mode shares in corridor

Note: LOS = level of service, O-D = origin-destination.

Table 3. Other ridesharing estimation methods.

Method	Ridesharing Application	Description	Comments
Emergency automobile occupancy	Estimates ridesharing potential for contingency planning	Apply automobile occupancy rate to work trips with common origin and destination zones	Lee and Glover used minimum occupancy of 3; Cheslow suggests 2.55; no empirical validation
Aggregate share	Usually estimates ridesharing demand at workplace	Transfer of observed modal share for ridesharing from existing program to new site	Reported modal shares from ridesharing programs vary greatly from site to site; many differences among ridesharing programs
Identification of potential ridesharers in population	Estimates areawide demand; estimates ridesharing potential at workplace	Potential determined by comparing characteristics of population against known characteristics of ridesharers	No known simple set of sociodemographic characteristics describes ridesharers; only common characteristic appears to be long commute
Household decision simulation games	Identifies possible responses (including ridesharing) to various policies	Household rearranges travel patterns on game board in response to various scenarios	Administration of game to more than small sample time-consuming; gives insight to possible changes in travel and activity patterns for various scenarios

tion to a new situation and also include the household-interaction simulation games.

RESEARCH NEEDS

Estimation techniques for ridesharing still present a challenge to transportation analysts for several reasons. Ridesharing is not strictly a private mode of transportation nor is it public. Travelers' decisions to rideshare are more complex than decisions to use either public transport or private automobile in that coordination with other travelers is required. Depending on the nature of the ridesharing program, some or all of this coordination becomes the responsibility of the travelers themselves; this increases the relative effort necessary to use this mode. Innovative ridesharing arrangements and promotional efforts are introduced regularly and predicting demand for these new situations compounds the problem for the analyst.

The following two proposed studies are seen to have an immediate impact on the improvement of ridesharing estimation techniques. The first is a multivariate analysis of ridesharing at employment sites. Since many ridesharing estimates are made by transferring a known modal share from one place to another, it would be extremely useful to provide a good set of factors for such transfer. These could be obtained from a multivariate analysis of a data set from a national sample of employment sites that contains the following information about each site: type of industry, number of employees, incentives for ridesharing, incentives for driving alone, degree of ridesharing assistance, number of ridesharing units by type (carpool, vanpool, buspool), and pool composition (intracompany, intercompany, with household members, with neighbors). The second study would be to simply field test a set of estimation techniques at several sites so that an assessment of accuracy, strength, and limitations could be made.

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Activity Flexibilities of Rural Households: Implications for Ridesharing

CHRISTIAN F. DAVIS

The research described in this paper deals with activity patterns and their relationship to travel needs in a rural area in eastern Connecticut during a typical weekday. It was part of a larger effort to determine the potential for dynamic ridesharing in a low-density area. Various types of activity flexibilities are examined based on the results of a home interview survey of 601 households in the 330-mile^2 Windham Planning Region. Activity flexibility in time was found to be very great except for work or school. With the exception of these two, it was found that 75 percent of all activities were judged to be not fixed in starting time. In fact, 37 percent of all activities could have occurred on a completely different day. Demands on the responsiveness of a ridesharing program should not be excessive since most activities are known well in advance. In the case of the sample households, only 5 percent of the recorded activities occurred with no advance notice and 75 percent were known 24 h in advance. The results indicate that an effective program to encourage ridesharing should recognize that activities occur with great regularity and hence can be scheduled far in advance or are quite flexible in time and can thus be rescheduled to be compatible with ridesharing.

There would appear to be little doubt that ridesharing is an effective strategy for conserving energy, increasing mobility, or achieving some favorable combination of the two.

For the most part, previous studies have focused on satisfying existing travel patterns that in turn are partly the result of habits gained during a period of cheap energy. The possibility of taking advantage of the underlying flexibility of the activities that give rise to the travel patterns has received little attention. It is suggested here that, within limits, not only can the transportation system adapt to travel patterns, but travel patterns can be adapted to the transportation system and that this adaptation can take place within the constraints established by our pattern of daily activities.

The research described in this report deals with activity patterns and their relation to travel needs in a rural area in eastern Connecticut. Of specific interest is the commonality in tripmaking and the flexibility of activity patterns in both spatial and temporal terms. The work was part of a larger effort (1) aimed at examining the range of benefits that could derive from making use of the excess capacity of the private automobile and the inherent flexibility of activity patterns through ride-sharing. It should be noted that, although the work trip was considered, it was not the major focus of the study.

GEOGRAPHIC AREA

The geographic area studied was the 10-town Windham Planning Region in eastern Connecticut. The Planning Region covers an area of approximately 330 $miles^2$ with an estimated 1977 population of 71 000, which gives a population density of 195 $persons/mile^2$. Density varies from 45 $persons/mile^2$ in Hampton to 3200 $persons/mile^2$ in the City of Willimantic (2).

The region is largely undeveloped and relatively rural and only 6 percent of its land area is built up (as opposed to being vacant) (2). Significant determinants of the character of the region in addition to its low density are the City of Willimantic (1977 population, 11 857) and the University of Connecticut at Storrs, which has a student enrollment of more than 17 000 and 4145 employees.

SURVEY DESIGN

The basic input data for all the analyses described in this report are the results of a home interview survey of 601 households in the Planning Region. Questions on the survey, taken during the period from November 1979 through May 1980, are restricted to a typical working day (Monday through Thursday), and only trips by residents of the area are reflected. The survey instrument consists of socio-demographic data pertaining to the household, activity patterns of household members during the day preceding the interview, flexibility of activities, and a series of questions dealing with attitudes toward ridesharing.

After consideration of several alternative sampling designs, the method of simple random sampling was chosen as the most appropriate in terms of data limitations precluding a stratified sampling model. The ultimate unit of analysis was the occupied housing unit from which data were collected via at-home interviews.

ACTIVITIES AND FLEXIBILITY

The time-geography model as described by Burns (3), among others, is helpful in visualizing the activity flexibilities and constraints examined in this study.

Without loss of generality, we consider motion in only one spatial dimension in a time-space coordinate system, as depicted in Figure 1. The path P represents the individual's trajectory through time and space and is not a trajectory in physical space since that trajectory remains a straight line. The slope of the trajectory is, of course, simply the inverse of the speed of the individual at any given point.

Note that if an individual wishes to engage in activity A_1, represented by a short, broad line, it would be impossible to also engage in activity A_3, since one can be at only one place at any given time, say t_3. In fact, all the shaded area between t_1 and $t_1 + L_1$ would be inaccessible to the individual. Moreover, if the maximum speed attainable were v (for simplicity, neglect acceleration and deceleration), it can be seen that all activities such as A_4 falling within the area abhcd would also be inaccessible. By similar arguments, if the individual wishes to engage in both activities A_1 and A_2, he or she is left with only the unshaded space-time prism (efgh) available.

Now consider the possible types of flexibility that might attach to an activity. For convenience we designate these as follows:

1. Translation, which allows the entire activity to be shifted in the temporal direction [for example, activity A_3 in the preceding discussion might be shifted to the position shown as activity A_3*, which allows participation (if the constraint imposed by activity A_2 is also removed)];
2. Extensional flexibility, which might allow for participation in activity A_4 if in fact the activity could begin at any time between t_4 and $t_4 + \Delta t_4$;
3. Substitution, which is simply the substitution of one activity for another, for example, activity A_5 for activity A_3 (note that the most obvious occurrence of this would be in the substitution of one geographic location for another);
4. Permutation, which involves both translation and substitution by switching the sequence of activities; and
5. Complete elimination of the activity from the daily pattern, probably the most extreme form of flexibility.

With this brief background, the technique can be used to help demonstrate the various degrees of freedom that give rise to flexibility. Figure 2 shows a hypothetical distribution of activities in time and one-dimensional space. In Figure 2 we denote an activity by A_{ij}, where i signifies the activity group according to the following classification:

Activity Category	i,j
Work	1
Participatory sport	4
Medical appointment	5
Convenience shopping	6

In our study there are 16 activity types (plus return home), which are grouped into categories by similarity. In general, there are a number of potential sites for each activity and a specific site is identified by the j-index. Thus in the simple example shown in Figure 2, there are three potential work sites (A_{11}, A_{12}, A_{13}), one potential site for participatory sports (A_{41}), three potential sites for convenience shopping (A_{61}, A_{62}, A_{63}), and one potential site for medical appointments (A_{51}). Note that unless flextime is being practiced, most work-type activities are fixed between, say, 8:00 a.m. and 5:00 p.m. In general, the time for a participatory sport is fixed by the participants and is constrained only by the availability of the facility. Thus, we have assumed in this example that the facilities would be available from 8:00 a.m. until 12:00 midnight. A similar situation holds in the case of a medical appointment, and very great flexibility exists for convenience shopping.

We now consider three individuals denoted by I, K, and M. Assuming that these individuals have the ability to travel at a speed v, we see that they have space-time prisms abcd, pqrs, and efgh, respectively. Thus, for example, it would be impossible

Figure 1. Space-time prism and activity.

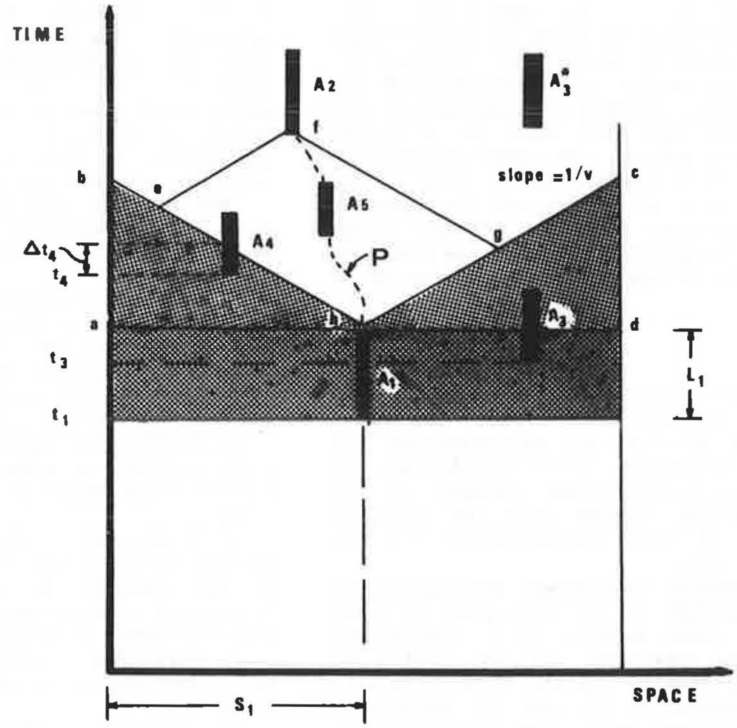
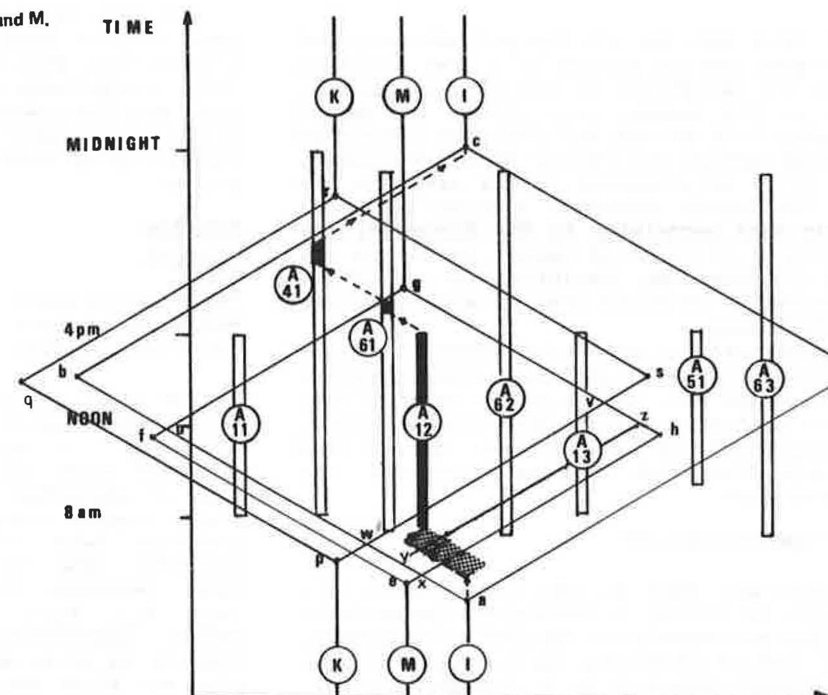


Figure 2. Feasible ridesharing strategy for I, K, and M.



for individual I to work at the location denoted by A_{11} without either relaxing his or her terminal constraints or not putting in a full day's work. He or she could, however, shop at the location shown by A_{63} between about noon and 4:00 p.m. Suppose for the moment that individual K had no transportation available and thus the potential space-time prism pqrs has been eliminated. However, we note that I's prism overlaps most of K's potential prism and it is this overlap that can be used to advantage in ridesharing. Assume now that activity sequences $\{A_{12}, A_{61}, A_{41}\}$, $\{A_{61}\}$, and $\{A_{12}\}$ have been established for I, K, and M, respectively. We note that I has established a specific time (6:00-7:00 p.m.) when he or she will be using the sports facility but that no further constraints have been applied to his or her convenience shopping (other than the fact that it will take about 0.5 h to complete).

RIDESHARING

To examine feasible ridesharing strategies, we can immediately observe that the prism wugv in Figure 2 is common to all three individuals but that neither A_{12} nor A_{41} is entirely within this prism, so there is no feasible strategy involving all three individuals for an entire tour. However, I and M have the prism xugh in common, and moreover this prism completely contains A_{12}. Since A_{12} is contained in the desired activity sequence of both I and M, ridesharing between these two individuals to this activity is feasible. Activity A_{61} could also be included since the duration is only 1 h. By continuing the above line of reasoning, a feasible ridesharing strategy involving all three individuals at one time or another can be developed, and the result is shown in Figure 2. In this strategy, I leaves home at 5:30 a.m. and picks up M at 7:00 a.m. and they share a ride to work; they arrive there at 7:30 a.m. After work, I drives M home, drops him or her off, and continues on to grocery shopping. I shops for 0.5 h and drives on to a sports event, for which he or she picks up K on the way. I and K leave the sports event at 8:00 p.m. and I drops K off at K's home and continues on; I reaches home at about 11:30. Note that in this example neither K nor M was required to provide his or her own transportation. Thus, M's effective space-time prism (if M does not have transportation available) becomes some fraction of yugz; the exact boundaries depend on I and K.

Several of the elements of temporal flexibility were mentioned earlier (e.g., convenience shopping can take place any time between 7:00 a.m. and 11:00 p.m. and is constrained only by its duration). Another element can be demonstrated by supposing that M's workday is 1 h shorter than I's. The additional 0.5 h, say, at each end could be thought of as an additional sacrifice in activity space or it could be viewed as a flexibility in the coupling constraint. In the latter context it becomes quite important in assessing feasibility of individual matches. We note in passing that the shaded area represents the activity space I has sacrificed to engage in ridesharing. In this particular case it is completely a result of route deviation, although, in the more general case, it could include space due to time incompatibility.

RESULTS

A total of 2943 activities (defined as an action by any member of a household that took place more than 0.5 mile away from the household) were reported in the survey. This amounts to 1.8 trips per person per day and 4.9 trips per household per day. The somewhat low values recorded for these rates probably reflect the large student population, the low income of the region, the fact that the respondent was unlikely to be aware of all the activities of the members of his or her household, and the definition of an activity.

Figure 3 shows the frequency distribution of the 16 activity types after excluding the return trip and grouping them into nine categories with reasonably similar characteristics. As might be expected, work is the single most frequently occurring activity (28 percent), followed closely by shopping (23 percent). The activities classified as school and after-school account for 14 percent and these are followed in order by serve passenger (11 percent), recreation (9 percent), community activities (4 percent), restaurant (4 percent), "other" (primarily personal business) (4 percent), and medical or dental (3 percent).

One section of the survey questionnaire attempted to quantify the types of flexibility described above. It is important to note that, with the exception of permutation, the flexibilities attach to the activities themselves and the constraints under examination are determined by requirements at the activity and not by some perceived time required to reach the next activity.

Table 1 presents the distribution of times given by the respondents in answer to the question, "What was the earliest time you could leave home for this activity?" Of the total of 1211 activities reported by the respondents, the 478 shown in Table 1 include only those where home is the starting point and those activities for which the respondent gave the information. Work activities showed the expected time constraints; the two hours between 6:00 a.m. and 8:00 a.m. included 58 percent of the earliest times the respondents could leave home for work. Small-item shopping exhibited a distribution later in the day; 35 percent of the respondents reported the earliest time they could have left home for these activities as between 12:00 a.m. and 12:00 p.m. At first glance, it would seem that the earliest one could leave home would be independent of activity type. The differences between types probably resulted from (a) difficulty in making clear to the respondent that the constraint lay at the home end and (b) the fact that a different subgroup of the total population was responding to the question for each activity. Keeping these facts in mind, the pattern is what might be expected for small-item shopping that originated from the home.

Other activities in Table 1 generally were concentrated in the afternoon hours in terms of the earliest time the respondent could leave home. For example, theater, spectator sports, participatory sports, after-school activities, public meetings, and restaurants were all more than 80 percent in the period between 12:00 noon and midnight in terms of earliest time and most of these were centered around 4:00-7:00 p.m. When the time constraints on all respondent activities originating from the home are considered, ignoring type, there is much less concentration in any one time period. Again, this would suggest that several different subgroups of the population are reflected. In response to a similar question dealing with the return home, the respondents indicated that all but 26 percent of their 362 returns could have occurred after 2:00 p.m. The most common time period for the latest return home was 4:00-6:00 p.m.; 33 percent of the respondents' trips occurred during this time. Interestingly, only a total of 16 percent of the respondents reported that they could return home between 8:00 and 12:00 p.m. at the latest. This seems to indicate that about 7:00 p.m. is the practical limit for returning home for the respondents.

Figure 4 shows, for the respondent, the proportion of activities of each type that had a fixed starting time. A closer examination of the data indicates that for work activities with a fixed starting time, 30 percent of respondents reported 7:00-8:00 a.m. as the starting time, followed by 29 percent who reported 8:00-9:00 a.m. as the fixed time. As expected, school-related activities with a fixed starting time were concentrated in the period 7:00-8:00 a.m. The other activities with a fixed starting time were scattered throughout the day. It should be noted that relatively few of the respondents' activities had a fixed starting time where the location of the previous activity was not home. This suggests considerable flexibility in starting

Figure 3. Distribution of activities in sample households by type (excluding return trip).

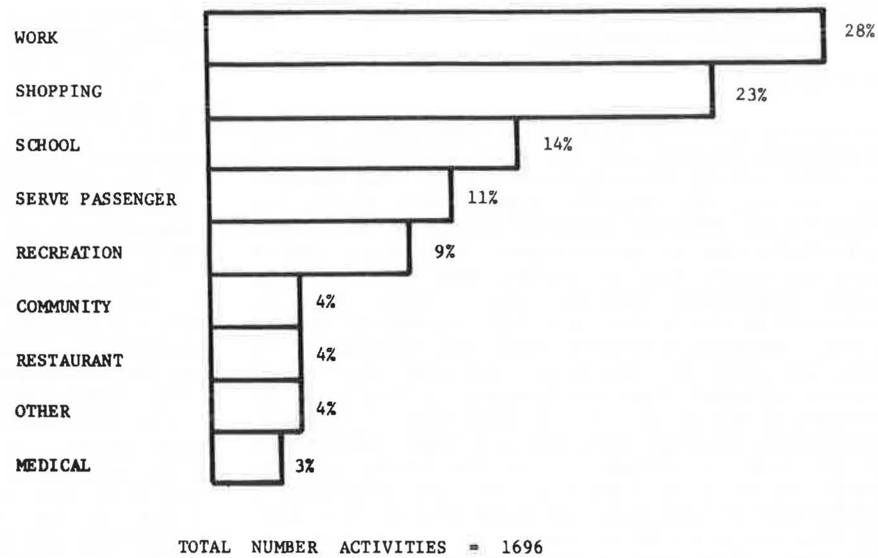


Table 1. Earliest time respondent could leave home by activity type.

	Percent of Total							
	Earliest You Could Leave Home?[a]							
Activity Type	1:00 a.m.-5:00 a.m.	5:00 a.m.-6:00 a.m.	6:00 a.m.-7:00 a.m.	7:00 a.m.-8:00 a.m.	8:00 a.m.-9:00 a.m.	9:00 a.m.-12:00 a.m.	12:00 a.m.-12:00 p.m.	No. of Activities
Work	6.0	9.0	27.1	30.8	8.3	0.7	18.1	133
Theater	-	-	-	-	-	-	100.0	4
Spectator sport	-	-	-	-	-	-	100.0	3
Participatory sport	-	-	-	-	-	16.7	83.3	12
Other recreation	-	-	6.7	-	23.3	13.3	56.7	30
Small-item shopping	1.0	1.0	1.0	10.3	26.8	24.6	35.3	97
Clothes/appliance shopping	-	-	-	20.0	-	10.0	70.0	10
Other shopping	-	-	-	28.6	14.3	14.3	42.8	7
Church	-	-	-	-	25.0	25.0	50.0	4
School	-	1.0	14.8	33.3	18.5	7.5	25.9	27
After-school activity	-	-	-	-	-	-	100.0	3
Voluntary association	5.3	-	5.3	5.3	5.3	10.6	68.2	19
Public meeting	-	-	7.1	-	-	12.5	80.4	8
Restaurant	-	-	-	-	-	15.8	84.2	19
Medical/dental/legal	-	-	-	10.5	26.3	10.6	52.6	19
Other[b]	-	3.6	9.6	14.5	9.6	24.0	38.7	83
Total	2.3	3.1	10.0	16.5	12.9	12.6	42.6	478

[a]Only for those activities where home is the starting point and for which respondent gave information.
[b]Approximately 41 percent serve passenger, 25 percent personal business, and 16 percent social or recreational; only 6 percent fixed in time.

times for most activities of the respondents.

Responses to a similar question regarding fixity of ending times showed a pattern similar to that for starting times, but the proportions fixed are generally somewhat smaller. As in the previous case, these data show relatively few activities for which there is a fixed ending time and where the location of the preceding activity is not home. This again suggests considerable flexibility of ending times for most respondent activities.

Figure 5 presents responses to the question dealing with coupling constraints: "If a ride were provided for you, how long would you be willing to wait at the location of the activity before starting that activity?" Excluded are activities for which the respondent did not give a waiting time and of course return-home activities. A large proportion of all the applicable activities (31 percent) involved no willingness of the respondent to wait. However, for 44 percent of the activities, the respondents said they would be willing to wait 15-30 min at that location before starting the activity. Longer waiting times of 30-60 min and more than 1 h were agreed to by only a small number (5 percent) of the respondents. This pattern suggests that for those respondents who indicate a willingness to wait before starting an activity, 15-30 min is the upper limit. Respondents' willingness to wait after completing an activity showed a pattern similar to that observed in Figure 5; 30 percent of all applicable activities fell in the no-wait category and 42 percent in the 15-30-min category. Small-item shopping was evenly divided: 35 percent of the respondents indicated no waiting time and 37 percent said 15-30 min. Willingness to wait longer than 30 min at the location of the activity after completing it was indicated for only 5 percent of all activities. The overall conclusion from these data is that, although for many activities respondents are not willing to wait at the location after completing the activity, many are willing to wait up to 30 min.

Questions shown below reflect an attempt to examine the possibilities of substituting or eliminating activities and to determine frequency and

Figure 4. Fixed and nonfixed starting times by activity type.

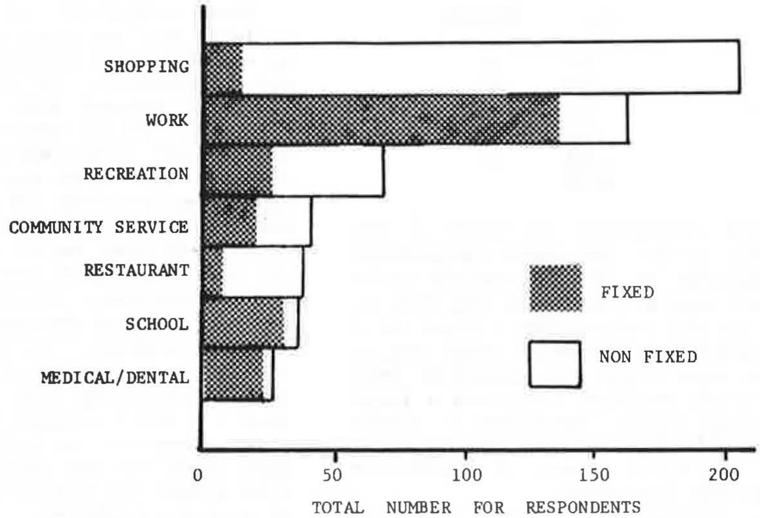
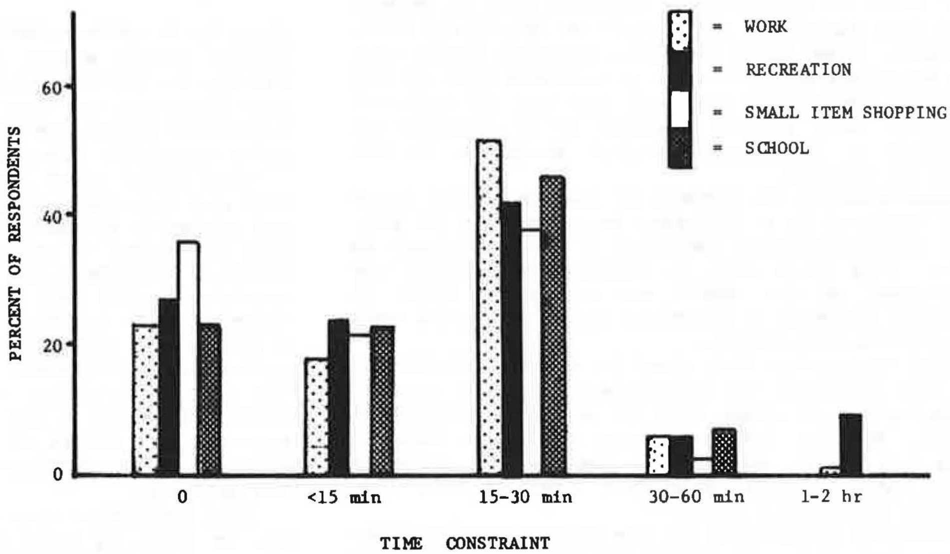


Figure 5. Time respondent willing to wait before activity by type.



advance knowledge of the activity. These questions were included not only to assist in the general analysis of the results, but to give maximum utility to the data for use in various matching algorithms.

1. How important do you think this activity is for the well-being of your household?

Response	No.	Percent
Very important	810	56
Important	312	22
Relatively unimportant	161	11
Unimportant	142	10
Do not know	12	1
Total	1437	

2. Would it have been possible for this activity to have occurred on a different day?

Response	No.	Percent
Yes	524	37
No	902	63
Do not know	6	<1
Total	1432	

3. Would it have been possible to complete this activity at a place closer to home?

Response	No.	Percent
Yes	203	14
No	1214	85
Do not know	8	1
Total	1425	

4. What is the usual frequency of this activity?

Response	No.	Percent
Daily	1100	46
Once/week	733	31
Once/month	253	11
Infrequently	281	12
Total	2367	

5. How far ahead of time did (you/they) know that this activity would occur?

Response	No.	Percent
No advance knowledge of time	75	5
<1 h	107	8
1-2 h	51	4

Response	No.	Percent
2-4 h	32	2
Same day but >4 h	85	6
24-48 h	209	15
>48 h but < one week	93	6
> one week	758	53
Do not know	10	1
Total	1420	

Note that statistics represented in Table 1 and Figures 4 and 5 apply to the individual respondents themselves; the remainder of the tabulations apply to all persons in the sampled households for whom it was possible to obtain the information. (Question 4 totals exclude 576 activities for which there was no answer.) Note also that since the questions were not asked for the return activity, there are a large number of inapplicable cases. (Question 5 totals exclude 1235 inapplicable activities.) The percentages are based on the total number of applicable cases for which data were available.

With regard to elimination of the activity, respondents felt that 78 percent of the recorded activities were important or very important for the well being of the household compared with 21 percent that were viewed as unimportant or relatively unimportant. Given these findings, it seems likely that the household would attempt to continue most of the recorded activities even if the use of personal vehicles were limited because of a shortage of gasoline or there were drastic increases in the price of gasoline.

Approximately 37 percent of the activities could have occurred on a different day, but only 14 percent could have been completed at a place closer to home. This would seem to indicate that either the activities of the sample are relatively fixed in terms of place or a conscious attempt is being made to minimize trip length.

The respondents were asked to provide information on the frequency of activities, and the general distribution of these data is shown in question 4 above. For the 2367 activities for which information was given, 46 percent occurred on a daily basis, whereas only 12 percent occurred less frequently than once a month.

Detailed examination of the survey results indicates that work and school are the two activities that make up the majority of the daily activities when return home is not considered, whereas shopping for groceries and other small items makes up a sizable proportion of the weekly activities. Shopping for small items also makes up the largest proportion of once-monthly activities and the second largest proportion of those activities that occur less frequently than once a month. The other categories, including banking, tended to make up an increasing proportion of the activities as the time interval between activities increased. The percentage distribution of the frequency of the activity for each of the types indicates that work and school are predominantly daily activities. Shopping, sports, recreation, and voluntary associations occur more often on a weekly basis, whereas theater, public meetings, and medical, dental, and legal activities occur less often. It is evident from the data that the frequency of the various types of activities varies considerably.

The data on how far ahead of time the persons in the sample knew they were going to participate in a given activity are shown in question 5. Only a relatively small proportion of the activities occurred without any advance notice (5 percent). In the vast majority of the cases (75 percent), the individuals knew at least 24 h ahead of time that they were going to participate in a given activity.

Some indication of the relationship between activity type and prior knowledge can be gained from an examination of activity patterns for the individual respondents. Of course, work activities included 78 percent that were known one week ahead, but more than 60 percent of participatory sports, school and after-school activities, and public meetings were known more than one week ahead. For small-item shopping, 28 percent of these activities were known 24-48 h in advance by the respondents. In fact, this time period was the second most common for the respondents and included 10 percent of all their activities. The respondents knew 24 h or more ahead of time of the occurrence of 39 percent of all their activities. In terms of short prior knowledge, only 6 percent of all the individual respondents' activities fell into the category of less than 1 h and 2 percent into the category of 1-2 h. Thus, comparing the percentages for the respondents with those for the sample as a whole suggests that role within the household influences prior knowledge of activity schedules.

CONCLUSIONS

If it is to achieve maximum success, any ridesharing program cannot afford to attempt to tailor ridesharing to randomly occurring requests; rather it must recognize and take advantage of the fact that activities either are regular or can be rescheduled to be compatible with ridesharing.

This study found that activity flexibility in time was very great except for work and school. With the exception of these two activities, it was found that 75 percent of activities were judged to be not fixed in starting time. In fact 37 percent of all activities could have occurred on a completely different day. In addition to these time flexibilities, a significant proportion of respondents (44 percent) indicated a willingness to wait for 15-30 min from the time of arriving at the site of an activity before the start of the activity if such a wait was required as a result of ridesharing. Similar figures apply to the respondents' willingness to wait after the activity.

Thus activities seem to be either quite inflexible in time, in which case they are known well in advance and occur in a narrow time band common to many persons, or quite flexible in time so that to a large extent schedules could be adjusted to be compatible with ridesharing.

Demands on the responsiveness of a ridesharing program should not be excessive, since most activities are known well in advance. In the case of the sample households, only 5 percent of the recorded activities occurred with no advance notice, and 75 percent were known 24 h in advance.

Flexibility in space is another matter. Only 14 percent of the recorded activities were perceived as not being performed as close to home as possible. More than one-third of those traveling farther than necessary for an activity cited tradition and personal desires as the reason.

Finally, although activities, with the exceptions noted, were found to be quite flexible in time, very few (21 percent) were perceived as unimportant or relatively unimportant for the well-being of the household. Thus total elimination of activities would generally have a significant impact on lifestyle.

Since activities are either regular with a high level of commonality in starting times (work, school) or very flexible (shopping) and are ordinarily known well in advance, it would appear that a matching program of modest sophistication could be quite effective for all trip types.

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Comparative Commuting Costs: Vanpooling, Carpooling, and Driving Alone

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The costs of alternative commuting modes are compared by developing and using models that recognize both time and travel costs. Vanpool survey data from the Baltimore region are used to calculate costs and find an equal-cost commuting distance beyond which vanpooling is cheaper than carpooling or driving alone. The distance is found to be approximately 18.5 miles for leased vanpools that provide front-door service and 30 miles for leased vanpools that pick up passengers at a few central places. However, front-door vanpools seem less workable for commuting distances beyond 30 miles. Equal-cost distance is shown to decrease, which makes vanpooling cost-effective for smaller commuting distances, as the result of various changes. These include increased fuel cost, an increase in the perceived cost of operating an automobile, employer subsidy, provision of tax rebates or free loans for purchases of vans, and elimination of free commuter parking. High-occupancy-vehicle lanes would encourage vanpooling but no more than other, less costly strategies. Lighter 7-passenger vans do not appear to be as cost-effective as do 13-passenger vans. The decrease in equal-cost commuting distance with perceived value of time suggests that vanpooling should be attractive to lower-income workers if they were given an opportunity to join a vanpool.

As part of a project to estimate the market for vanpooling in the Baltimore region, models have been developed to compare the costs of participating in a vanpool with the costs of other modes that could be used for commuting long distances to work. Five modes are considered: driving alone, carpooling, front-door-service vanpools, central-pickup vanpools, and subscription bus. The commuting distance is assumed to be beyond that of regular bus transit, so mode is not included in the cost comparisons.

The cost models build on an equation developed by Johnson and Sen (1). They include perceived value of time as well as travel costs; thus inconvenience factors are recognized as well as money spent. The models are then applied to the Baltimore region by using data obtained locally, particularly from a vanpool survey conducted by the Mass Transit Administration (MTA) of the Maryland Department of Transportation (MDOT) in 1980 (2).

The relative perceived costs of the modes as given by the models depend on commuting distance. For each pair of commuting modes there is a commuting distance called the equal-cost commuting distance beyond which one of them (vanpooling in particular) is less costly. Insofar as cost is a factor in mode choice, the models can be used to find the commuting distance over which a particular mode would be most attractive. Recent work has emphasized the importance of social factors in the decision to join a vanpool, but cost savings remain important (3-5).

COMMUTING-COST MODELS

Drive Alone

Equation 1 shows the round-trip cost of commuting as perceived by a person driving alone a distance L between home and work. The first part of the expression represents the perceived time costs of making the trip and the second part, the perceived cost of operating the automobile. Clearly, the less aware a driver is of the real costs of operating an automobile, the cheaper the drive-alone trip becomes.

$$\text{Round-trip commuting cost (drive alone)} = 2L[(T/S) + C_{oa}] \quad (1)$$

where

- L = one-way direct commuting distance from home to work,
- T = perceived value of time (\$/h),
- S = average speed during drive-alone trip to work or during line-haul portion of carpool or vanpool trip to work, and
- C_{oa} = cost of operating an automobile as perceived by person driving alone (\$/mile).

Carpool

Equation 2 estimates the round-trip cost of commuting as perceived by a member of a carpool. The carpool is assumed to meet at a central place that is an average distance (d) from the homes of the poolers and then travel a distance [L - (d/2)] from the pickup place to work. (After joining the pool, members must travel an extra distance d/2 each morning and afternoon.) The first term represents the time and travel costs of the daily trip to the pickup place and back. The second term represents the trip between pickup and work. Note that carpoolers' perceived cost of operating an automobile, C'_{oa}, may be different from that of a person driving alone. Results of surveys indicate that both S and S_p depend on commuting distance, but that S_p, the average speed between home and pickup place, never exceeded 20 mph.

$$\text{Round-trip commuting cost (carpool)} = 2d[(T/S_p) + (C'_{oa}/O_{hp})] + 2[L - (d/2)][(T/S) + (C'_{oa}/O_{pw})] \quad (2)$$

where

d = distance driven by carpool or vanpool member to pickup place (miles),
S_p = average speed during trip to pickup place,
C'_{oa} = cost of operating an automobile as perceived by person already carpooling ($/mile),
O_{hp} = vehicle occupancy from home to pickup place, and
O_{pw} = carpool occupancy from pickup place to work.

Front-Door-Service Vanpools

The MTA vanpool survey (2) indicated that 80 percent of the vanpools picked up passengers at a few central places. However, a number of vanpool groups were interviewed in which most of the passengers were picked up near their front door. The operating characteristics of these vanpools were sufficiently different to warrant separate classification. Equation 3 divides the daily costs of participating in a front-door vanpool into four parts. The first term, which represents the perceived time costs per passenger of picking up and distributing, assumes that the average passenger is in the van during half of its pickup and delivery time. The second term represents the round-trip perceived time cost of the line-haul portion of the trip. The third term represents the daily operating costs of the van. The round-trip distance (D) traveled by the van exceeds the direct round-trip commuting distance (2L) but must be paid for by the passengers. The last term represents the fixed costs that must be paid to a leasing company or the owner for the use of the van. It is a real cost that must be shared by the passenger regardless of mileage traveled and is one barrier that has tended to limit vanpooling to longer commuting trips thus far.

$$\text{Round-trip commuting cost (front-door service vanpool)} = 2T(t_p/2) + 2T(t_L) + D(C_{ov}/P) + (C_{fv}/21P) \quad (3)$$

where

t_p = one-way pickup time for vanpool,
t_L = one-way line-haul time between last pickup place and work,
D = round-trip distance traveled by van each day (miles),
C_{ov} = cost of operating van ($/mile),
C_{fv} = monthly fixed costs for van ($/mile), and
P = number of passengers in vanpool.

Central-Pickup Vanpools

Equation 4 shows the daily costs per passenger in a vanpool that picks up passengers at a few central pickup places. One term is added to the previous vanpool cost expression. It represents the perceived costs of the trip to pickup place and return. If costs of driving alone and for vanpooling are being compared (C_{oa}), the automobile operating cost as perceived by a person now driving alone is used in this first term. If carpooling and vanpooling are being compared, then C'_{oa}, the automobile operating cost as perceived by an active carpooler, is used.

$$\text{Round-trip commuting cost (central-pickup vanpool)} = 2d[(T/S_p) + (C'_{oa}/O_{hp})] + 2T(t_p/2) + 2T(t_L) + D(C_{ov}/P) + (C_{fv}/21P) \quad (4)$$

Subscription Bus

In localities where the demand is sufficient, a commuter bus provided by the transit authority or a private operator provides an alternative to the modes discussed previously. If the bus picks up passengers at several places, then the cost expression would be similar to that for a central-pickup vanpool, and appropriate values for C_{ov} and C_{fv} would be inserted. An express bus serving one pickup place would have pickup time $t_p = 0$.

COMPARATIVE COSTS

The models outlined above were applied to the Baltimore region by using assumed or local survey values for the parameters. The numbers obtained are listed below:

C_{oa} = $0.093/mile for persons driving alone,
C'_{oa} = $0.165/mile for carpool vehicle,
C_{ov} = $0.19/mile for vans,
C_{fv} = $416/month for leased van,
C_{ov} = $1.25/mile for 45-passenger bus,
C_{fv} = $1360.80/month for 45-passenger bus,
d = (0.1)L, approximately, up to a limit of 4 miles,
D = (2L + 10.6) for front-door-service vanpools,
= (2L + 5.4) for central-pickup vanpools,
O_{hp} = 1.3,
O_{pw} = 2.5,
P = 13.2 passengers,
S = 10 + L up to limit of 45 mph,
S_p = 10 + L up to limit of 20 mph,
T = $6/h,
t_p = 0.5 h for front-door-service vanpools,
= 0.3 h for central-pickup vanpools,
t_L = 0.78 (L/S) for front-door-service vanpools, and
= (L - 3.3)/S for central-pickup vanpools.

The values of C_{oa} and C'_{oa} are average results obtained by using data from a local commuting survey conducted in the fall of 1980. They are based on responses to a question asking for daily perceived driving costs (including parking). Commuting mileage was measured from maps. For an average 1980 automobile using $1.25/gal fuel and getting 17 miles to the gallon ($1.25/17 = $0.073/mile), $0.093/mile calculated for persons now driving alone corresponds to a perceived cost of fuel plus 2 cents/mile. The carpool operating cost of $0.165/mile was obtained by multiplying the perceived automobile operating cost per carpool member ($0.066/mile) times a regional average carpool occupancy (O_{pw}) of 2.5 (6). Carpool members perceived a higher automobile operating cost. However, both of these perceived costs are less than the actual cost of operating an automobile. It will be shown later that cost of operating an average automobile in 1980 was approximately $0.20/mile.

Values of C_{ov} and C_{fv} for vans are 1980 numbers obtained from VANGO, Inc., the organization that promotes vanpooling in Maryland. With C_{ov} = $0.19/mile and C_{fv} = $416/month, each member of a 13.2-passenger vanpool must pay $0.19/13.2 = $0.014/mile and $416/(21 x 13.2) = $1.50/day. For a 50-mile round-trip van the monthly fare would be $46.62.

The values of C_{ov} and C_{fv} for 45-passenger buses are assumed 1980 values, based on MTA experience.

Vehicle occupancy between home and pickup place

(O_{hp}) was obtained in local park-and-ride surveys (7). The same value, 1.3, was used for vehicles traveling to vanpool pickup places.

The value of time used for the base calculation, $6/h, is assumed. The literature contains a wide range of values of time, depending on the type of travel decision being made (8). The value of $6/h, equal to half the wage rate of a person earning $24 000/year, was chosen because it led to reasonable agreement between the cost models and results obtained in the MTA vanpool survey (2). For simplicity, the same value of time was used for driving alone, carpooling, driving to and from pickup, and line-haul travel.

Values for the other parameters are average results obtained from responses gathered in the vanpool survey. The value given for d does not mean that the distance driven to the pickup place was limited to 4 miles but merely that for direct commuting distances L in excess of 40 miles, d no longer correlated with L and had an average value of 4 miles.

The same may be said of the values for S and S_p. Once vans have picked up all passengers, their average line-haul speed (S) was the same as that for a single-occupant car driven directly between home and work.

It is interesting to note that in the Maryland survey, pickup time (t_p) did not correlate with L. Some of the longest pickup times were for vans traveling short commuting distances.

There was great scatter in the line-haul times (t_L) of the front-door service vans. However, it did correlate with a fraction (0.78) of drive-alone time (L/S). The average line-haul distance for central-pickup vanpools was equal to L - 3.3, so $t_L = (L - 3.3)/S$.

The values for front-door-service vans are based on 26 pools and, for central-pickup vans, on 88 pools.

If the locally obtained values given for all the parameters are inserted in the four cost equations, the value of the direct commuting distance L at which costs of two competing modes become equal (equal-cost commuting distance) can be calculated. The results are calculated below:

Front-door vanpool versus drive alone: L = 18.8.

Front-door vanpool versus carpool: L = 18.3.

Central-pickup vanpool versus drive alone: L = 30.2.

Central-pickup vanpool versus carpool: L = 29.5.

The values of L shown do not indicate the vanpool or carpool distance, but the direct one-way home-to-work commuting distance at which vanpooling becomes the less costly alternative. The cost comparisons assume that the vans are leased.

The equations indicate, first, that the cost of vanpooling drops below that of driving alone and that of participating in a 2.5-person carpool at approximately the same commuting distance (18.3-18.8 miles for front-door-service vanpools and 29.5-30.2 miles for central-pickup vanpools). In the Maryland vanpool survey, nearly half of the vanpoolers had formerly carpooled. The results calculated above indicate that vanpooling should be equally attractive on a cost basis to carpoolers and to solo drivers, were they given the opportunity.

At first glance, it is surprising that front-door-service vanpools, which consume an average of a half-hour each morning and afternoon picking up and distributing passengers, should be cost-competitive at a smaller commuting distance than central-pickup vanpools. However, the front-door service does eliminate the round trip to the pickup place, which is costly in terms of time and money. (For a 2.5-mile trip at 20 mph to and from the pickup place and a one-way direct commuting distance L = 25 miles, the cost of the trip to pickup and back is $2.13 compared with $11.52 for the rest of the trip to and from work.)

The MTA vanpool survey (2) verifies the calculated difference between the two types of vanpools. The average one-way commuting distance (L) was 19.7 miles for front-door vanpools and 30.9 miles for central-pickup vanpools, which indicates that front-door-service vanpools are indeed attractive at intermediate commuting distances.

The lower cost per mile of front-door-service vanpools cannot be extended to very large commuting distances. In most cases, the half-hour pickup time on which the calculations were based would not be maintained for longer commuting trips. Only two front-door-service vanpools responding to the MTA survey had values of L greater than 31 miles.

For a value of time T = $6, carpooling is less costly than driving alone for the commuting distances considered. A comparison of the two was thus not calculated.

In calculating the cost of commuting on a 45-passenger subscription bus, it was assumed that 50 percent deadheading would be required. That is, for each revenue mile, the bus would have to be driven a mile empty. This allows for traveling from a downtown storage facility, for example, to the morning pickup place and then returning to the facility at the end of the day. By using this assumption, an unsubsidized bus carrying 45 passengers costs more than vanpooling for all commuting distances, so a comparison was not calculated. If the bus could be stored near the morning pickup place overnight to reduce deadheading, commuter bus would be competitive for L greater than 18-20 miles.

CHANGES IN REAL AND PERCEIVED COMMUTING COSTS

The calculations to this point match common vanpool experience: The pools tend to be made up of persons traveling a long distance to work. As long as this is true, vanpooling will constitute a minor portion of overall ridesharing activity. In the Baltimore region, only 18 percent of work trips are longer than 20 miles and 3 percent are longer than 30 miles. Nevertheless, the equal-cost distance of vanpools versus driving alone is slightly larger than that versus carpooling because C_{oa} = $0.093/mile is used in the comparison. For comparing vanpooling with carpooling, C_{oa} = $0.165/mile is used.

Thus, the estimated potential for vanpooling in the region is very limited unless some of the cost parameters in the equations change. Now that we have estimated the length of trip over which vanpooling is cheaper than driving alone or carpooling, let us see what the effect on the equal-cost commuting distance would be if the value of some of the perceived or real time-cost or travel-cost parameters were changed. With this, we may see an expansion of the potential market for vanpooling.

Increased Fuel Cost

First, consider an increase in the cost of fuel. Keep the same perception of automobile operating costs as that used previously:

For solo drivers: C_{oa} = ($1.25/17 mpg) + $0.02/mile
= $0.093/mile
or (fuel cost/17) + 0.02.

Table 1. Variation in equal-cost commuting distance with changes in real and perceived commuting costs.

Cost	Front-Door Vanpool Versus Drive Alone[a]	Front-Door Vanpool Versus Carpool[b]	Central-Pickup Vanpool Versus Drive Alone[c]	Central-Pickup Vanpool Versus Carpool[d]
Fuel ($/gal)				
1.50	16.7	17.7	23	26.2
2.00	13.4	16.3	11	21.2
3.00	10.5	14.2	6	15.2
4.00	8.3	13	-	10.1
Increased C_{oa} ($/mile)				
0.13	13.6	-	13	-
0.20	9.2	17	4	20.5
0.163[e]	11	18.5	7	30
T ($/h)				
12	26	20.4	57	48.8
10	23.2	19.6	50	41.5
8	20.9	18.8	43	35.5
6	18.8	18.3	30.2	29.5
4	16.2	17	19.6	24.1
2	13.6	15.5	14.3	22
0	10.5	13.1	11.4	20.5

[a]Base case, L = 18.8. [b]Base case, L = 18.3. [c]Base case, L = 30.2. [d]Base case, L = 29.5. [e]Subcompact car.

For carpools: C'_{oa} = ($1.25/17 mpg) + $0.092/mile = $0.165/mile or (fuel cost/17) + 0.092.

For vanpools: C_{ov} = ($1.25/10 mpg) + 0.065 = $0.19/mile or (fuel cost/10) + 0.065.

If the cost of fuel were to increase at a rate greater than inflation, as has happened in the past, the calculated equal-cost commuting distance would decrease, as shown in Table 1. Fuel cost is shown in 1980 dollars. The base calculations shown above are repeated for comparison. Not surprisingly, driving alone is more sensitive to fuel cost than is carpooling. Central-pickup vanpools improve from being less costly beyond 30 miles at a fuel cost of $1.25/gal to being less costly beyond 15 miles at a fuel cost of $3/gal. Front-door-service vanpools show less gain because their half-hour morning pickup time looms relatively larger for the shorter commuting distances at which costs of the competing modes become equal.

Change in Perceived Cost of Operating Automobile

Now suppose that the cost of fuel remains at $1.25/gal, but an educational campaign succeeds in raising the perceived cost of driving to more realistic levels. First, assume that the average solo driver is made to recognize that the real cost of operating an average car is as follows:

Cost	Amount/Mile ($1980)
Fuel	0.073
Tires and oil	0.007
Maintenance	0.045
Insurance	0.005
Total	0.13

The insurance cost shown is the portion of automobile insurance--approximately 15 percent--that depends on mileage driven. The results of a change in attitude are shown in Table 1. The equal-cost commuting distance for front-door-service vanpools versus driving alone drops from 18.8 miles to 13.6 miles. For central-pickup vanpools, the equal-cost commuting distance drops from 30 miles to 13 miles. Carpools are not included in the comparison because the average perceived operating cost for them is already assumed to be $0.165/mile.

Automobile operating costs should also include mileage depreciation. Other ownership costs such as insurance, loan interest, and age depreciation will not be assigned to the work trip because, in most cases, the commuting vehicle is used for other trips as well. However, driving to work does cause wear. If a conservative estimate of 7 cents/mile (initial cost minus salvage value equal to $7000 and 100 000 miles of use) is added to operating costs of $0.13/mile, the total automobile operating cost is $0.20/mile.

Table 1 lists the equal-cost commuting distance calculated on the assumption of C_{oa} = $0.20/mile. In this case, vanpooling is less costly than driving alone for commuting distances exceeding 9.2 and 4 miles. According to the models, vanpooling is now less costly than carpooling at commuting distances exceeding 17 and 20.5 miles. In these cost comparisons, the operating cost of vans is held at $0.19/mile because the mileage depreciation is being paid for as part of the monthly leasing cost.

Suppose now that a commuter is aware of the full cost of operating an automobile but considers the expense of driving alone--or carpooling--in a subcompact car having a fuel efficiency of 35 miles/gal. Then, with all other costs at the 1980 level, fuel cost decreases from $0.073/mile to $1.25/35 = $0.036/mile. C_{oa} drops from $0.20/mile to $0.163/mile. Doubling of fuel efficiency decreases automobile operating costs 19 percent. The new equal-cost commuting distances were calculated above. Vanpooling is still less costly than driving alone for commuting distances longer than 7-11 miles. Competition of vanpools with subcompact carpools is not significantly different from the base case.

Change in Perceived Value of Time

The last perceived parameter to be considered and listed in Table 1 is the value of time, T. Values of T from zero to $12/h, in addition to the base value of $6/h, were used in the cost models. According to the models, the cost-competitiveness of central-pickup vanpools is more sensitive to perceived value of time (L decreases more with decreasing T) than is the cost-competitiveness of front-door-service vanpools because the driving time to and from pickup increases proportionally to L. Driving-alone cost is also more sensitive to T than is carpooling cost. Insofar as value of time is linked to salary, the calculations indicate that vanpooling, if made available, should be attractive to low-income workers over smaller commuting distances than to high-income workers. The present predominance of high-income vanpoolers [the average 1980 household income in the MTA vanpool (2) survey was $30 061] may be the result of the type of employer that has cooperated in promoting vanpooling thus far as well as longer work trips made by high-income workers (6).

VANPOOL INCENTIVES

The previous section showed the effect of the cost of fuel and changes in perceived costs on the cost-competitiveness of vanpooling. There are also a variety of control measures that could be carried out to encourage vanpooling by reducing its cost relative to other commuting modes or by facilitating the initial purchase of a vehicle.

Financial Measures

All the vanpool calculations thus far have been for

Table 2. Variation in equal-cost commuting distance as result of vanpooling incentives.

Incentive	Front-Door Vanpools Versus Drive Alone[a]	Front-Door Vanpools Versus Carpool[b]	Central-Pickup Vanpools Versus Drive Alone[c]	Central-Pickup Vanpools Versus Carpool[d]
Company subsidy of 22 percent	15.9	16.1	20	20.9
Tax rebate to purchasers of pool vans of 15 percent	16.3	16.2	19.3	21.4
Interest-free van loans to purchasers of pool vans	15.1	15.3	17.5	17.3
Seven-passenger vans	21.6	21.4	33.9	38
Priority parking	16.4		25	
Parking fee of $2	9.7	15.3	0	15.9
HOV lane	14.1		10	-

[a]Base case, L = 18.8. [b]Base case, L = 18.3. [c]Base case, L = 30.2. [d]Base case, L = 29.5.

a leased van. Maryland vanpool data show that fares in company-owned and owner-operated vanpools are 22 percent lower than those in leased vanpools. This implies that corporations are subsidizing their vanpools in various ways, so that, for company-operated pools, altered cost figures should be used in the cost equation. If the van operating cost (C_{ov}) and the monthly fixed cost (C_{fv}) are reduced approximately 22 percent, from $0.19/mile to $0.15/mile and from $416/month to $324/month, respectively, the equal-cost commuting distance will decrease as shown in Table 2.

If an individual purchased a $12 000 van with a four-year 14 percent loan in 1980, the monthly payment would be $343.20. Assuming a salvage value of $3800 after four years, a 13-member pool should pay a total of $278.86/month toward the loan. Monthly fixed costs (C_{fv}) would then amount to the following:

Cost	Amount/Month ($)
Loan payment	278.86
Insurance	46.18
License, fees	2.50
Total	327.54

If the owner were to receive a 15 percent federal tax rebate on the $12 000 purchase of the van for pooling, and the $1800 rebate were spread over four years, the monthly rebate would be $37.50. Net fixed costs for the van would be decreased to $290.04. If that value of C_{fv} along with the base value C_{ov} = $0.19/mile are used in the models, the equal-cost commuting radius would be reduced to the values shown in Table 2. Legislation providing such tax relief is being discussed by the United States Senate and House of Representatives (Bill S239, Senator David Durenberger, Congressional Record, Jan. 22, 1981).

An alternative financial proposal is to provide low-interest loans for purchase of vanpools. If a totally interest-free four-year loan of $12 000 could be obtained, the monthly fixed cost (C_{fv}) would be as follows:

Cost	Amount/Month ($)
Loan payment	185.66
Insurance	46.18
License, fees	2.50
Total	234.34

The results of calculations shown in Table 2 indicate that low-interest or interest-free loans could be the most powerful of the three financial incentives discussed. The equal-cost distance would be reduced to 15.1-15.3 miles for front-door vanpools and 17.3-17.5 miles for central-pickup vanpools.

Smaller Vans

The calculations carried out earlier for a 45-passenger subscription bus suggest considering a smaller, lighter van for pooling. If a four-year $8000 loan at 14 percent was obtained for a seven-passenger van in 1980, the monthly loan payments minus salvage-value rebate would be $175.11. The monthly fixed costs would then be as follows:

Cost	Amount/Month ($)
Loan payment	175.11
Insurance	36.94
License, fees	2.50
Total	214.55

If the smaller van gets 13 miles to the gallon of fuel, the operating costs could be as follows:

Cost	Amount/Month ($)
Fuel	0.096
Tires and oil	0.007
Maintenance	0.051
Mileage depreciation	0.006
Total	0.16

When these values of C_{fv} and C_{ov} are used in the models, the per-passenger costs are higher than those for 13-passenger vans and the equal-cost commuting distances shown in Table 2 are longer than those for the base case. Lighter 7-passenger vans are not so cost-effective as are 13-passenger vans.

Parking Management

One parking measure that is already in common use is the provision of convenient priority parking spaces for pool vehicles. If solo drivers are forced to park in a less convenient place (for example, one that is a 2.5-min walk further from the entrance to work), a 5-min ($0.50) time penalty is being imposed each day. The penalty is small, yet it causes a 2- to 5-mile reduction in the equal-cost distance. The penalty would not be applied to carpools, so their competitive status relative to vanpools would remain unchanged.

A much more drastic impact, comparable to the one produced by $3 fuel (Table 1), would result from the imposition of a $2 parking fee on all commuting vehicles. The cost for a drive-alone commuter would be $2/day; for a carpooler, $0.80/day; and for a vanpooler, $0.15/day. As shown in Table 2, vanpooling becomes less costly than 2.5-person carpooling for all distances beyond 15-16 miles and less costly than driving alone for even shorter distances.

High-Occupancy-Vehicle (HOV) Lanes

To conclude, consider a more costly measure--the implementation of a reserved highway lane for carpools and vanpools. Assume that the facility carries pool vehicles from their last pickup place to the edge of the central city or work area at 50 mph. Following that, they must travel central-city streets for 2 miles at 11 mph. If that change in speed (S) is applied to the cost models, the equal-cost distance for vanpools versus driving alone is reduced from 18.8 and 30.2 miles to 14.1 and 10 miles. The impact is significant, but no more than that of $2 fuel and less than that of a $2 daily parking fee. To implement HOV lanes in all commuting corridors would be prohibitively expensive.

CONCLUSION

Although employer promotion, computer-matching facilities, and social factors are significant in the growth of vanpooling, an important question remains: Will it result in a net time and money savings for the commuter? The cost relations developed in this paper are an attempt to express both time and money costs associated with commuting quantitatively, so some cost comparison can be applied to alternative commuting modes for trips of different lengths. By using values obtained from surveys in the Baltimore region, the models indicate that carpooling is cheaper than driving alone at all distances considered. A front-door-service vanpool becomes less costly than carpooling or driving alone for commuting trips longer than 18 miles one way, approximately, but becomes less workable for trips longer than 30 miles. Vans that pick up passengers at a few central places become more competitive at 30 miles and beyond. These results are based on costs existing in 1980 for leased vans.

If the cost of fuel increases or drivers' perception of automobile operating costs becomes more realistic or ways to make van purchasing easier are initiated or free commuter parking is eliminated, vanpooling becomes cost-competitive for a much larger portion of work trips. If the commuting distance at which central-pickup vans are cost-competitive is decreased from 30 miles to 20 miles--achievable in several ways, according to the calculations--vanpooling's share of the commuting market in Baltimore could increase by a factor of more than 6.

The connection between value of time and salary is not certain. However, the decrease in equal-cost commuting distance with decreasing value of time suggests that vanpooling, now a commuting mode used primarily by high-salaried workers, should be equally or more attractive to low-salaried employees. Promotional efforts should recognize this.

A final point can be made concerning the encouragement of ridesharing by preferential treatment of high-occupancy vehicles, for example, the implementation of traffic lanes reserved for carpools or vanpools. They should certainly be considered as part of new or widened freeway projects. However, to implement them in all corridors, thus to produce a significant impact on ridesharing, would be very costly and difficult to enforce. Furthermore, the models indicate that the impact of HOV lanes would be no greater than that of $2 gasoline, of motorists becoming aware of the real cost of operating an automobile, or of the elimination of free parking.

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