be more of an annoyance than a problem. However, the manufacturer is currently attempting to reduce internal car noise levels.

Also, the transit needs, guidelines for accessible design, and customer or patron demands will require modifications to the current design. These modifications may include: (a) provision of power-operated hoistway doors and car doors, (b) larger car size and capacity than the basic minimum elevator provided for handicapped persons in Belgium [1100x1400 mm (43x55 in)], (c) provisions to permit the rescue of persons (possibly severely handicapped) trapped in a stalled elevator by using outside help, (d) emergency voice communication system, (e) specially marked car bin operating panel that can be used by the blind, and (f) possibly an independent governor and safety device if the safety-nut principle used by this manufacturer is not accepted by U.S. code authorities.

It is recommended that, based on the data presented herein and on the observations made from the on-site inspection, a demonstration of screw-column elevators at an existing transit station should be considered. A demonstration will permit data to be collected that will identify how these elevators will perform in a transit environment.

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Notice: The Transportation Research Board does not endorse products or manufacturers. Trade and manufacturers' names appear in this paper because they are considered essential to its object.

Park-and-Ride at Shopping Centers: A Quantification of Modal-Shift and Economic Impacts

STEVEN A. SMITH

The purpose of this research was to quantify the effects of park-and-ride facilities at shopping centers on commuter travel and shopping behavior. A survey of commuters at three shopping centers in Montgomery County, Maryland, was conducted to estimate these impacts. The analysis demonstrated that there can be a significant economic benefit to shopping-center operators for allowing commuter parking to occur on their parking lot. Survey results indicate that between 25 and 45 percent of park-and-riders shop at the shopping center on a typical day on their way to or from work. Approximately two-thirds of this shopping activity is either diverted from other shopping locations or in newly induced shopping. For the shopping centers surveyed, the average increase in sales due to the presence of park-and-ride activity is $5/park-and-ride/day. Also, the presence of the park-and-ride facility, in itself, is responsible for 10-30 percent of the park-and-riders choosing to use transit or form a carpool.

Shopping centers have been prime locations for commuter park-and-ride activities for many years. Many such centers and retail sites are located along major public transit corridors and are ideal locations for catching a bus or meeting a carpool. Peak parking demands for shopping centers do not normally coincide with commuter parking peaks, and this creates an opportunity for more effective use of the parking supply. However, shopping-center operators are not generally enthusiastic about commuter parking on their property, perceiving that commuter parking can adversely affect business and the image of the center. In addition, there remain questions about how a park-and-ride lot influences travel behavior, and thus whether these facilities, in themselves, are responsible for including shifts to more efficient modes of travel (i.e., bus and carpool).

Although much of the park-and-ride activity takes place without any formal concurrence from the shopping center, there are also many examples of formal arrangements between shopping centers and local government agencies. This research was designed to quantify the potential benefits of commuter parking to shopping-center operators so that both the engineering community and shopping-center management can make knowledgeable decisions on this issue. Also, it may help the shopping-center management in dealing with problems perceived with informal commuter parking.

STUDY DESIGN

This study was one task of a larger study entitled Parking Policies Study for Montgomery County, Maryland, sponsored by the Maryland-National Capital Park and Planning Commission. Montgomery County is located to the northwest of the Washington, D.C., metropolitan area. It is a rapidly urbanizing suburban county with almost 600 000 residents and an employment of more than 300 000. The study of commuter park-and-ride activity was made to answer the following questions:

1. What modal shifts can be attributed to the presence of a park-and-ride facility at a shopping center? Would commuters simply park in other locations, or is there some actual diversion among alternate modes of travel?
2. What are the economic benefits of commuter parking to shopping-center operators?
3. Does the patronage of the shopping center by commuters divert shopping trips from a peak to an off-peak period, possibly justifying reductions in parking requirements for those centers that permit commuter parking?

To answer these questions, a survey was designed to question commuters on their travel and shopping habits at three commuter park-and-ride lots in Montgomery County. The three locations were Montgomery Mall, Wheaton Plaza, and Aspen Hill Shopping Center. Both Montgomery Mall and Wheaton Plaza are

regional shopping malls and are formally designated as park-and-ride lots by the Montgomery County Department of Transportation. The Aspen Hill center serves as an informal, but heavily used, facility, and has nearly 200 commuter vehicles parked on the lot. It contains a major grocery store, drug store, and clothing store as well as a variety of smaller shops. The commuters consumed approximately 20 percent of the Aspen Hill center's parking capacity but did not affect parking availability for other shoppers. The Montgomery Mall and Wheaton Plaza lots accommodated 460 and 320 vehicles, respectively, on the days of the survey in early November 1981, which was slightly less than 10 percent of the parking supply. Walking distances to the stores from the commuter parking locations were as follows: Montgomery Mall, 300-500 ft; Wheaton Plaza, 500 ft; and Aspen Hill, 100-300 ft. The shopping centers range between 9 and 14 miles from downtown Washington.

Surveys were conducted in favorable weather conditions on typical commuting days between 6:30 and 9:00 a.m. Interviews were conducted as persons who park at the lot exited their vehicle to form a carpool or catch a bus. Usually the interviews were conducted orally, but in some cases the questionnaire was given to the park-and-rider to be filled out while waiting either for the bus or other carpool members. In other instances, a questionnaire and mailer were handed to the respondent with the hope that it would be returned. The questionnaire used is given below:

1. How often do you park here?
   a. Usually 5 days a week
   b. 3-4 days a week
   c. 1-2 days a week
   d. Less than that
2. Do you normally park here to:
   a. Catch a bus?
   b. Meet a carpool?
   c. Other (specify)
3. Did you park here yesterday?
   a. Yes
   b. No
   (If no, skip to question 8)
4. If the lot had not been here, what would you have done to get to work yesterday?
   a. Would have parked nearby (within walking distance) and caught the same bus or carpool
   b. Would have caught the bus or met the carpool somewhere else
   c. Would have driven all the way to work
   d. Other (specify)
5. Did you shop at any of the stores here yesterday on your way to or from work?
   a. Yes
   b. No
   (If no, skip to question 8)
6. About how much did you spend?
7. If this lot had not been here, what would you have done about obtaining yesterday's purchases?
   a. Bought the same things at this location on the way to or from work
   b. Bought the same things at this location at a different time (list probable day and time as best you can)
   c. Bought the same things at a different location (list probable day and time as best you can)
   d. Not bought the things
   e. Other (specify)
8. In a typical week, how often do you shop at these stores when you park here for your trip to work?
9. In a typical week, how much do you spend when you park here for your trip to work?

An excellent response was achieved from the surveys at each of the sites, with 50-60 percent of all park-and-riders in the lot during the survey day responding. Many of those interviewed were quite suspicious of the objective of the survey, some being fearful that the lot could be disbanded as a fringe facility. Although this could have resulted in some dishonest responses, it was felt that the face-to-face interview methodology, which required quick thinking on the respondents' part, combined with the specificity of most of the questions (e.g., "Did you shop here yesterday?") minimized such bias. If bias exists, one would probably expect it to occur more with the questionnaires mailed back, because those respondents would have had more time to contrive false answers. However, the comparison of the mail-backs with the personal interviews for several key questions indicated that little bias existed. The mail-backs, which comprised only 10 percent of the returns, were therefore combined with the other returns. In all, the following number of completed questionnaires were received: Aspen Hill, 112; Montgomery Mall, 256; and Wheaton Plaza, 147.

RESULTS

Travel and Use Characteristics

The table below (in response to Question 1) indicates that, at each shopping center, at least 65 percent of the commuters reported using the lot for park-and-ride usually 5 days/week. [Ed. note: For the following tables, the left column (a., b., c., and so on) refers to the choices given under each of the questions in the survey. Please refer back to the questionnaire for explanations of the responses.]

	Aspen Hill		Montgomery Mall		Wheaton Plaza	
Frequency	No.	Percent	No.	Percent	No.	Percent
a.	76	68	185	72	97	66
b.	16	14	43	17	23	16
c.	12	11	12	5	16	11
d.	8	7	15	6	11	7
Total	112		225		147	

Including those who use the lot on the average of 3-4 days/week brings the total figure of regular use to between 82 and 92 percent. The table below shows that most (between 74 and 94 percent) are using the lot to catch buses as opposed to using it for carpool or vanpool formation (responses to Question 2):

	Aspen Hill		Montgomery Mall		Wheaton Plaza	
Purpose	No.	Percent	No.	Percent	No.	Percent
a.	82	74	241	94	118	84
b.	28	25	7	3	19	13
c.	1	1	8	3	4	3
Total	111		256		141	

The table below indicates the responses to the hypothetical question of what the park-and-rider would have done to get to work had the park-and-ride lot not existed (responses to Question 4):

	Aspen Hill		Montgomery Mall		Wheaton Plaza	
Alternate Trip Choice	No.	Percent	No.	Percent	No.	Percent
a.	30	34	79	35	16	14
b.	35	40	34	15	77	68
c.	11	13	64	29	12	11
d.	12	13	46	21	8	7
Total	88		223		113	

Although the question was hypothetical, experience with that line of questioning revealed that people could fairly readily formulate an alternative. Other than a before-and-after analysis of travel patterns at a recently instituted or removed park-and-ride lot, this is the only way to estimate the modal shift induced by the park-and-ride facility itself (i.e., exclusive of other factors that induce people to park-and-ride).

Both Aspen Hill and Wheaton Plaza are situated near a multitude of other retail uses while Montgomery Mall is relatively isolated from other sources of parking. For the former two, between 74 and 82 percent would have caught the same bus or carpool. In the case of Montgomery Mall, up to 30 percent may have chosen to drive all the way to work, but only about 10 percent in the cases of Aspen Hill and Wheaton Plaza. The relative isolation of Montgomery Mall may have contributed to the more significant levels of diversion. Thus, the provision of park-and-ride lots may divert a percentage from single-occupant automobile trips, but many would still find some other informal park-and-ride arrangements.

Shopping-Center Patronage by Park-and-Riders

The table below indicates the proportion of those who parked at the fringe lot the day prior to the interview and who also shopped at the shopping center on the way to or from work (responses to Question 5):

Shop Here	Aspen Hill		Montgomery Mall		Wheaton Plaza	
Yesterday?	No.	Percent	No.	Percent	No.	Percent
Yes	40	44	94	42	28	25
No	50	56	129	58	83	75
Total	90		223		111	

The highest percentage was Aspen Hill at 44 percent and the lowest was Wheaton Plaza at 25 percent. Aspen Hill is a smaller facility with parking located closer to the stores. This combined with the type of stores (grocery and drug store as primary tenants) may explain why Aspen Hill had the highest shopping frequency. The park-and-ride lot area was farthest away from the shopping facilities at Wheaton Plaza, which possibly explains the less-frequent shopping there.

In a question related to the above table ["About how much did you spend?" (answered only by those who shopped at the center yesterday)], the average purchases were as follows: Aspen Hill, $14.10; Montgomery Mall, $25.56; and Wheaton Plaza, $16.30. One could compute the average daily purchase amounts per fringe lot user by multiplying the dollar values above by the percentage of those shopping at the center yesterday. These amounts are as follows: Aspen Hill, $6.20; Montgomery Mall, $10.61; and Wheaton Plaza, $4.08.

To determine the true increase in purchases brought about by the existence of fringe parking, one must also identify what the commuters would have done about their purchase had they not been able to park all day at the fringe lot. It is possible that many of the purchases may have been made at the same center anyway, in which case the actual benefit to the shopping center operator is reduced.

The table below indicates what those commuters who had made purchases yesterday would have done in the absence of the fringe lot (responses to Question 7):

Alternate Purchase Preferences	Aspen Hill		Montgomery Mall		Wheaton Plaza	
	No.	Percent	No.	Percent	No.	Percent
a.	8	24	7	8	4	12
b.	1	3	14	15	4	12
c.	20	61	53	55	14	45
d.	4	12	17	18	7	22
e.	0	0	4	4	3	9
Total	33		95		32	

Between 8 and 24 percent said they would have stopped by on the way to or from work anyway. A relatively small percentage (3-15 percent) said they would have come back to that same location at a different time. The largest proportion--the majority in two cases--would have bought the things at a different location. Respondents indicated that typical alternatives would include other shopping centers near home or stores close to the work place. A significant percentage (12-22 percent) stated they would not have made the purchases and thus could be labeled as induced shopping. The percentage of yesterday's shopping trips that could be legitimately claimed as an increment caused by the presence of the fringe lot would be the sum of the percentages of items not bought and items bought at a different location. These would be: Aspen Hill, 73 percent; Montgomery Mall, 73 percent; and Wheaton Plaza, 67 percent.

Applying the above percentages to the average daily purchase of a fringe parker yields the incremental average daily purchase per parker that could be attributed to the presence of the fringe lot: Aspen Hill, $4.53; Montgomery Mall, $7.75; and Wheaton Plaza, $2.73. In other words, the decision by the shopping-center operator to allow commuters to use the parking lot would increase daily shopping-center sales by the above amounts for each commuter that uses the lot. The average of the three locations is about $5/day. Thus, 100 daily parkers could add $500 to the center's daily sales or $120 000 over the course of the year (weekends and holidays excluded). For a smaller center such as Aspen Hill, the 200 commuters parking at the lot would represent an increase in sales of approximately 2 percent. For the larger centers, an increase of 0.5-1 percent would be typical. The sales increases would be most significant at convenience-type stores, especially grocery and drug stores. Earnings are significantly greater than the incremental cost of maintaining the parking spaces set aside for commuters.

As a check on the validity of some of the responses, particularly the average purchase amounts, two additional questions were asked about typical weekly shopping habits. The table below indicates that a small minority never shop at the center on the way to or from work and the majority shop 1-2 days/week (responses to Question 8):

Frequency of Shopping (days per week)	Aspen Hill		Montgomery Mall		Wheaton Plaza	
	No.	Percent	No.	Percent	No.	Percent
Usually 5	5	5	3	1	2	2
3-4	32	29	33	15	15	11
1-2	50	46	151	66	73	55
<1	11	10	29	13	13	10
Never	11	10	12	5	30	22
Total	109		228		133	

The mean frequency of shopping ranges between 1.3 days/week at Wheaton Plaza to 2.0 at Aspen Hill.

Table 1. Alternate times of purchase had the fringe lot not existed.

Alternate Times	No of Responses			Total	
	Aspen Hill	Montgomery Mall	Wheaton Plaza	No.	Percent
Buy at this location					
Weekday					
Morning	0	1	0	1	8
Evening					
12:00-4:00 p.m.	0	0	0	0	0
4:00-6:00 p.m.	0	0	1	1	8
After 6:00 p.m.	0	0	0	0	0
Time uncertain	0	0	0	0	0
Weekend					
Morning	0	5	1	6	46
Evening					
12:00-4:00 p.m.	0	3	2	5	38
After 4:00 p.m.	0	0	0	0	0
Total	0	9	4	13	100
Buy at other location					
Weekday					
Morning	0	0	0	0	0
Evening					
12:00-4:00 p.m.	0	7	0	7	16
4:00-6:00 p.m.	2	8	1	11	25
After 6:00 p.m.	6	5	2	13	30
Time uncertain	2	0	0	2	5
Weekend					
Morning	2	6	0	8	19
Evening					
12:00-4:00 p.m.	0	0	0	0	0
After 4:00 p.m.	0	0	0	0	0
Time uncertain	1	0	1	2	5
Total	13	26	4	42	100

Dividing the mean by 5 days/week should yield a value close to the percentage of fringe parkers who shopped at the stores yesterday. Remarkably, these values differ by only 1-2 percent for Aspen Hill and Wheaton Plaza and 10 percent for Montgomery Mall.

Likewise, the weekly purchase amount shown in the table below should roughly agree with the average weekly purchase amount computed from the "yesterday's trip" statistics (responses to Question 9):

Item	Purchase ($)		
	Aspen Hill	Montgomery Mall	Wheaton Plaza
Avg weekly purchase	25.13	28.27	19.28
Weekly purchase computed from "yesterday's trip" statistics	31.00	53.05	20.40

In each case, the amount specified from Question 9 was higher than the amount computed from "yesterday's trip" statistics. Except for Montgomery Mall, however, the difference is less than 25 percent, which is a relatively close agreement considering the subjective nature of the question.

The above results are somewhat similar to another study at four suburban shopping centers, which found that only 6 percent of the commuters who parked at the lots did no shopping at the centers. Nearly a quarter of the commuters spent more than $35/week at the centers, while more than 40 percent spend $1-$10/week at the centers (1). If there is any loss of other business because of the presence of the commuters (e.g., making it less convenient for other shoppers), this would reduce the net benefit.

Displacement of Peak Shopping Trips

A possible additional benefit of the fringe lot to shopping centers is the displacement of trips from the peak parking time (typically Saturday afternoons) to a period of less demand. This could conceivably justify a reduction in the parking requirements for centers that allow commuter parking, which results in an economic savings in construction of parking if such displacement is significant.

This hypothesis was tested by asking those who made purchases yesterday when they would have made them had the lot not existed. As could be imagined, the very hypothetical nature of this question made it difficult to answer concretely, and some people could not adequately respond. Of those that did respond, Table 1 summarizes the findings. For those that would have bought the things at the same location (only 13 samples), 84 percent would have made the purchases on the weekend (typically Saturday). Nearly 40 percent would have gone in the afternoon, which coincides with the peak parking time. This represents only about 1 percent of all the commuters surveyed, however.

For those who would have bought the items at a different location, 75 percent would have made the purchase on a weekday, according to the time distribution shown in Table 1. Purchases between 12:00 and 4:00 p.m. (16 percent) would be primarily near the work location, and those after 4:00 p.m. would probably tend to be at different shopping centers near the home. It is apparent, however, that any diversion of shopping trips from the peak shopping period is quite small, and a reduction in the number of parking spaces required based on the initial hypothesis cannot be justified.

SUMMARY

The analysis demonstrated that there can be a significant economic benefit to shopping-center operators for allowing commuter parking to occur on their parking lot. Survey results indicate that between 25 and 45 percent of park-and-riders shop at the shopping center on a typical day on their way to or from work. Approximately two-thirds of this shopping activity is either diverted from other shopping locations or is newly induced shopping. For the shopping centers surveyed, the average increase in sales due to the presence of park-and-ride activity is $5/park-and-rider/day. Also, the presence of the park-and-ride facility, in itself, is responsible for 10-30 percent of the park-and-riders choosing transit or carpooling.

Designating a portion of a parking lot for park-and-riders will be most attractive for convenience-type shopping centers and for locations along radial arterial streets. The percentage increase in sales will be greatest for smaller centers as long as no parking capacity problems are created. Although the economic benefits to shopping-center operators will vary by location, type, and size of center, public agencies should consider soliciting the cooperation of shopping-center operators in establishing park-and-ride facilities. Benefits will be derived (a) by the shopping-center operator as long as there is an adequate parking supply for all customers, (b) by the commuter in that work and shopping trips are more easily linked, and (c) by the public agency in reduced need for additional parking facilities and in reduced vehicle travel.

ACKNOWLEDGMENT

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Potential and Cost of Commuter or Regional Rail Service

E.L. TENNYSON

For approximately 100 years, railroads have carried commuting passengers between home and work in nine major metropolitan areas in the United States and Canada. These operations, with one exception, have demonstrated a stability of patronage not usually present in public transit by highway. In more recent years, Toronto has instituted a new, successful, and growing commuter or regional railway system, which indicates that the potential for such service is contemporary as well as traditional. Currently, fuel consumption and currency inflation are two of the most serious national problems. Highway traffic problems are closely related. At least in theory, commuter or regional rail service can mitigate all three of the adverse effects to the mutual benefit of all concerned. The potential usefulness of such commuter or regional rail service is analyzed to determine the demographic characteristics that contribute to its effectiveness. The results are reviewed to test the viability of commuter or regional rail service in other possible areas—either additional corridors in the 10 metropolitan areas currently served or new services to cities served only by highway transit. The possible reduction in federal transit operating assistance and the ever-present need for cost-effectiveness in urban public transit require rigorous cost analysis and economic advantage to justify any commitment to new or expanded service. Labor, energy, and other cost factors are analyzed to determine the potential economic viability of such rail service vis-à-vis other transit alternatives.

Urban transportation of passengers can be provided by highway or railway. Air travel is much too energy intensive and expensive for short trips and would be physically impractical in central business districts (CBDs) without ground transportation to support it. Water transportation is not possible for most urban areas and, although still useful in unique circumstances, this mode has been abandoned as impractical in most of those cities that used it in the past.

In most cases, the primary alternatives for effective urban transportation are highway and rail. All highways function together as a single ubiquitous system, but rail transit is divided into three physically similar but institutionally different types of service and operation:

1. Heavy rail rapid transit, which is incapable of street operations;
2. Light rail, or street railway, which is best used off-street; and
3. Regional or commuter rail, which uses freight railroad track.

Regional or commuter rail passenger service is superficially the easiest to implement because it can, where feasible, use existing rights-of-way coincident with other rail activity.

The efficiency of rail rapid transit would usually commend it for all urban rail passenger service, except for the high installation cost and the requirement for high volumes of travel. Regional or commuter rail is used to avoid the high capital cost of rail rapid transit and attendant requirements for high-volume travel. Light rail can be used in place of commuter rail where freight and intercity passenger movements can be relegated to off-peak or middle-of-the-night hours. Regional or commuter rail service is most appropriate for existing suburban trackage with modest travel volumes, at least at the outer extremities.

Commuter or regional rail service is well worth consideration where it can offer faster travel than city transit service (approaching automobile competitive speeds), where it costs less to provide than automobile travel plus parking, and where it removes more than 600 passengers/peak hour (one-way) from congested streets, thus creating the equivalent of an additional traffic lane without the cost.

INVENTORY OF SERVICES

To study and evaluate the usefulness and viability of regional rail service, existing services are reviewed herein to develop their characteristics. Table 1 (1-3) delineates the regional rail routes in the United States and Canada, grouped by operator in their respective metropolitan areas. Some of the data are a bit arbitrary, as some passengers and mileage are common to more than one line or route, but the representation is generally valid.

MODES

Regional rail service is operated in four different modes, which can be combined practically into eight alternatives:

1. Conventional train operation with locomotives,
2. Locomotive-powered trains in push-pull operation,
3. Diesel self-propelled cars or trains operated without locomotives, and
4. Electric multiple-unit train operation (without locomotives).

All four modes serve passengers quite similarly, except that electric multiple-unit trains offer much faster service. It is also a more economical service for frequent operation. Otherwise, the difference among modes is largely technical, but with economic variations.

The push-pull mode is most efficient in simple point-to-point operation, particularly if two cab-control cars are employed per train to permit drop-