TRANSPORTATION ALTERNATIVES IN RURAL COMMUNITIES: A FEASIBILITY ANALYSIS

Lynn L. Reinschmiedt and Steven W. Murray

Transportation is a vital element in our daily lives. Access to jobs, shopping, and other services depends upon some form of transportation. The principal means of transportation in the United States continues to be the automobile. Census figures show that in 1975, 84.7 percent of all workers in this country and 84.5 percent of the workers in non-metropolitan areas used the automobile to get to work (U.S. Bureau of the Census).

Members of the non-metropolitan work force are at a disadvantage compared to their urban counterparts because few alternatives to the automobile exist. Public transportation, in one form or another, was used by about 15 percent of those living and working in central cities, while only seven-tenths of 1 percent of the individuals who lived and worked in non-metropolitan areas used public transportation in 1975 (U.S. Bureau of the Census).

There are several reasons for the lack of transportation alternatives in rural areas, including the reluctance of rural people to use public transportation. Areas with low population densities do not generate the traffic volume needed to sustain public transit as readily as do densely populated areas.

The rural work force faces real economic difficulties now because of the increased cost of transportation to and from jobs. Because of increased energy-related costs and general inflationary pressures, the consumer price index for private transportation (1967=100) increased from 111.1 in 1970, to an average of 246.5 through September, 1980 (Bureau of Economic Analysis). The worker who spent $1.11 to get to work in 1970 now spends $2.46.

The economic plight of rural workers is worsened because most commute to relatively low-wage jobs (minimum wage, in many cases). Thus, the primary dependence upon increasingly costly private transportation, in combination with low paying jobs, and, in many instances, relatively long distances to work pose a real threat to industry in rural areas.

Non-agricultural industries in rural areas can be predominantly classified as "footloose." "Footloose" industries are normally drawn to areas of relatively inexpensive surplus labor (Tweeten and Brinkman). If this labor supply is threatened or diminished because workers find it uneconomical to commute, the comparative advantage of rural areas in attracting non-agricultural industry may be affected.

OBJECTIVES

The primary purpose of a study initiated in 1980 by the Community Development Department of the Mississippi Cooperative Extension Service and the Department of Agricultural Economics of the Mississippi Agricultural and Forestry Experiment Station was to address rural transportation issues. The research was designed specifically to determine the travel-to-work characteristics of rural Mississippi workers, to estimate the commuting costs to Mississippi workers, and to evaluate the economic feasibility of van pools and car pools as alternative forms of transportation. A case-study approach was utilized in the analysis.

DATA COLLECTION AND RESEARCH PROCEDURES

Plants selected for the study met certain conditions. The selected manufacturing plants were located in rural communities of less than 10,000 population and no closer than 25 miles to a population center of 25,000. They were labor intensive rather than capital intensive. Resource-based plants, such as saw mills and agricultural processors, were eliminated as potential sites to guarantee that the industries selected would represent so-called "footloose" industries.

Subject to these restrictions, three rural Mississippi factories with employment levels of 232, 64, and 146 were selected. Production workers in each plant completed questionnaires designed to provide the necessary journey-to-work information. In addition, each worker was asked to des-

Authors are Assistant Professor, Department of Agricultural Economics, Mississippi Agricultural and Forestry Experiment Station; and Extension Resource Development Specialist, Community Development, Mississippi Cooperative Extension Service. No senior authorship is implied.

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ignate his residence on county road maps provided. Worker residence data were collected on two of the three plants surveyed. Management at the third plant did not wish to have its employees provide this information. Journey-to-work data for this plant were evaluated and compared with the other two plants; given the lack of worker residence data, it was not possible to evaluate alternative transportation modes for the third plant.

Car pooling and van pooling were evaluated as alternative transportation modes. Automobile cost data were developed, using the U.S. Department of Transportation's "Cost of Owning and Operating an Automobile" publication series. The actual vehicles as reported in the plant surveys were classified into categories: standard, compact, and subcompact automobiles, and pickup trucks. Department of Transportation cost series for the actual age of the vehicle or the closest year for which figures were available were used as the basis for cost estimates. Modifications were made in order to reflect current costs and Mississippi conditions. For example, the Department of Transportation includes as part of ownership costs an estimate for road tolls and parking fees. This cost component was removed from the cost estimates utilized because they were not reflective of rural Mississippi. The consumer price index for private transportation was used to inflate cost figures from the earlier price series to account for current cost conditions. The total cost of commuting to and from work of the plant work force was a summation of individual vehicle costs as represented by the work force's motor fleet.

Base cost data for vans were obtained from Webb et al. and Department of Energy van pool costs estimates. These figures were also adjusted to reflect current costs and local conditions. Assuming a 5-year life for the van, the total cost per mile was calculated to be 43 cents.

Routes for the car pool and van pool alternatives were developed using a lockset, or Clark-Wright, procedure. The ROUTE algorithm developed by Hallberg and Kriebel was used for this analysis. Actual worker residence data for two of the surveyed plants were used as inputs in the algorithm that generated the van pool and car pool routes. The assignment of routes by this computer routine is heuristic, and an optimal solution is not guaranteed. But, given the cost of optimizing routines for problems of this nature, this procedure generates routes that are reasonably efficient and readily applicable to a wide range of transportation problems.

EMPIRICAL RESULTS

Selected socioeconomic and journey-to-work characteristics for the three Mississippi manufacturing plants are presented in Table 1. Average

TABLE 1. Journey to Work Summary Data, Three Rural Mississippi Labor Intensive Manufacturing Plants, 1980[a] [b]

Characteristic	Plant Identification A	B	C
Number of workers	232.00	64.00	146.00
Average age of workers (years)	28.00	34.20	30.50
Percent males in workforce (%)	60.40	87.50	19.30
Average hourly wage	$ 4.82	$ 5.20	$ 3.75
Average one-way distance to work (miles)	11.10	11.80	13.60
Average one-way commuting time (minutes)	18.10	21.10	23.60
Total commuter passenger miles per day (miles)	5,150.00	1,510.00	3,971.00
Total man hours commuting per day (hours)	140.00	45.00	115.00
Total monetary cost of assembling labor force per day[c]	$ 812.00	$ 230.00	$ 476.00
Average per worker monetary commuting costs per day	$ 3.50	$ 3.59	$ 3.26
Total value of employee time spent commuting per day[d]	$ 214.00	$ 77.00	$ 142.00
Percent of workers sharing rides (percent)	44.40	29.70	60.70
Percent of male workers sharing rides (percent)	36.60	30.40	55.20
Percent of female workers sharing rides (percent)	59.50	25.00	62.10
Total cost of assembling work force per day[e]	$1,026.00	$ 307.00	$ 618.00
Average model year of commuting vehicle	1973	1975	1976
Average value of commuting vehicle	$1,502.00	$1,896.00	$2,452.00

[a] Plant names and locations are withheld in agreement with confidentiality requests of plant management.
[b] Data derived from surveys undertaken in the summer of 1980.
[c] Mileage costs for the worker's vehicle fleet were based upon U.S. Department of Transportation figures adjusted to account for current costs. See text for further discussion.
[d] Value of time spent commuting was valued at one-third the individuals' wage rate (Manning).
[e] Sum of monetary costs and value of workers' commuting time.

employee age at the three plants ranged from 28 to 34.2 years. Employment at two plants, B and C, was dominated by one sex, while Plant A had a more equal sex distribution. Plant B's labor force consisted of 87.5 percent men, and Plant C's force was 80.7 percent women.

Distance to Work

The average one-way distance to work was similar for the three plants surveyed. Distances of 11.1, 11.8, and 13.6 miles were found for Plants A, B, and C, respectively (Table 1). These distance-to-work figures reveal that the sampled Mississippi workers travel farther to work than do most workers. Nationally, the average distance to work for all workers in 1975 was 9 miles, and the average for non-metropolitan workers was 9.2 miles. With a weighted average distance to work of 12.07 miles, the rural Mississippi workers sampled traveled 31 percent farther than the national non-metropolitan average.

Commuting Time

One-way commuting times of 18.1, 21.1, and 23.6 minutes were estimated for Plants A, B, and C, respectively. Nationally, the 1975 average commuting time for workers was 20 minutes. For non-metropolitan workers, 1975 statistics indicated that rural workers spent an average of 15.2 minutes getting to work (U.S. Bureau of the Census). On a weighted average basis, rural Mississippi workers spent 34 percent more time commuting than did the average U.S. non-metropolitan worker.

Ride-sharing Participation

The numbers of individuals who participated in a ride-sharing arrangement were quite high. Overall, 44.4, 29.7 and 60.7 percent of the workers for Plants A, B, and C, respectively, indicated that they shared rides. The sampled Mississippi workers tended to car pool more than did the Census Bureau's 1975 sample.[1] The 1975 national figures showed that 19 percent of all workers and 20.5 percent of all non-metropolitan workers participated in car pooling arrangements (U.S. Bureau of the Census). On a weighted average basis, 47.6 percent of the Mississippi sample shared rides.

National statistics indicate that men commute longer distances than women; however, Plant C, with a predominantly female work force, had the longest commuting distance. Also, the women in Plants A and C showed a higher tendency to car pool than did the men. Previous research has shown that men tend to car pool more than women (Margolin and Misch). The deviations of these journey-to-work statistics from national norms should not be interpreted as changes in trends or representative of conditions other than those represented by the surveyed plants. However, they do point out the differences in commuting habits and patterns across the plants surveyed, and suggest that further research into the causes of these differences is needed for full understanding of commuting behavior. For example, these differences could be attributed to skill requirements, population densities, and/or socioeconomic conditions.

Cost of Commuting

Workers incur two types of cost in commuting. The first is the actual monetary expense of owning and operating a vehicle, or the fare paid to someone else to take them to work. The second is the opportunity cost for time utilized in traveling to work. Time invested in commuting could have been spent on leisure, family activities, a second job, or other activities.

Based upon the estimated per-mileage cost and distances traveled, the average daily monetary costs of commuting to work per worker were $3.50, $3.59, and $3.26 for Plants A, B, and C, respectively (Table 1). Assuming a 40-hour work week and current average wage rates, the workers at the three plants spent between 8.6 and 10.8 percent of their gross earnings on transportation to and from work.

The estimated daily monetary costs of assembling the entire work force were $812, $230, and $476, respectively, for Plants A, B, and C (Table 1). If time spent commuting is assumed to be a consumption item that lowers individual total utility, a cost can be assigned to this time. A cost equal to one-third of the workers' wage rate was assigned to time spent commuting (Manning). The total cost of assembling the labor force, which included the opportunity cost of time spent commuting in addition to actual monetary outlays, was estimated at $1,036, $307, and $618 per day for the plants surveyed.

Alternative Modes of Transportation

Given that transportation-related costs are expected to continue increasing, what can be done to cut the costs that individual commuters incur? At some point, some workers may perceive that the income and intangible benefits derived from working are insufficient to offset the costs of getting to and from work, child care, and the overall disutility of working. The point at which this would occur depends upon individual preferences, attitudes toward work, and financial circumstances.

The remainder of this paper examines what, if anything, can be done to lower the cost of commuting to jobs. Two alternatives were evaluated: a situation in which all workers participate in car pools consisting of up to four persons each, and a second situation in which the manufacturing plant provides a van service for its employees. The results of these two alternatives were examined and compared with the current situation. Results of this analysis are presented for the two plants, A and B, for which worker residence data were available.

Car Pooling

The car pooling alternative allowed up to four people in each car. The car pool was assumed to originate in the morning and end in the evening at the driver's residence. The transportation algo-

[1] Although the Census Bureau data reflect 1975 price conditions and, therefore potentially different commuter attitudes toward ride-sharing and commuting arrangements, they are the most recent data available for comparison. However, census data do reflect the large, post-1973 embargo fuel-related increases, and should reflect at least a partial reaction on the part of commuters to these changes.

rithm assigned 73 different routes consisting of 47 four-person, 8 three-person, and 2 two-person car pools for plant A, and 16 routes consisting of 15 four-person, and 1 three-person car pools for plant B.

Car pooling substantially reduced the total mileage traveled. Under current journey-to-work arrangements, totals of 4,307 and 1,218 miles were traveled each day for Plants A and B, respectively. The car pooling arrangement reduced these figures to 1,437 and 685 miles, respectively (Table 2). From an energy conservation standpoint, car pooling could potentially reduce daily gasoline consumption by 225 gallons if each vehicle got 15 miles per gallon.

Surprisingly, average one-way travel time would not increase significantly for Plant A, where average commuting time increased from 18.1 to 18.2 minutes with the car pool alternative (Table 2). The car pool arrangement would increase Plant B's worker travel time from 21.1 minutes to 26.5 minutes. The difference is attributed to the low worker population density for Plant B, with its work force of 64 employees. The widely dispersed work force in this case increased the total commuting time.

Significant individual worker cost savings can be attributed to car pooling. Daily per-worker costs dropped from $3.50 to $1.30, and from $3.59 to $2.29, for Plants A and B, respectively (Table 2). Correspondingly, total monetary journey-to-work costs would drop from $812 to $301 for Plant A, and from $230 to $144 for Plant B. With the increase in commuter time, the car poolers' cost of time spent in transit increased from $214 to $226 for Plant A, and from $77 to $97 for Plant B. In summary, car pooling could save $511 and $86 per day in monetary costs for these two plants, respectively.

Car pooling did not decrease Plant B's worker commuting cost as much as it did for workers at Plant A. The low population density of Plant B's work force required car pools to travel greater distances than those at Plant A. This is reflected in the fact that car pooling arrangements reduced total vehicle miles by 67 percent for Plant A and only 44 percent for Plant B.

Van Pooling

In evaluating van pooling, the driver was assumed to be a plant worker. He (she) would originate the van route in the morning and complete it in the evening at his (her) residence. The following figures represent the total cost that would have to be covered if such a system were implemented. This analysis assumes that all workers at the plant participate in the van pool operation.

The analysis indicated that the work force of Plants A and B could be accommodated by 18 and 6 12-passenger vans, respectively. The number of vans could potentially be reduced by making multiple trips with some of the vans. Where worker residence concentration is high, as it would be in the town where the plant was located, multiple trips with the same van could be made without imposing undue hardships on workers in terms of early arrival at the plant; however, multiple trips were not permitted in the model.

TABLE 2. Summary Data for Alternative Transportation Modes, Industries A and B, 1980

Characteristic	Plant A			Plant B		
	Current	Carpool	Vanpool	Current	Carpool	Vanpool
Total vehicle miles per day (miles)	4,307.00[a]	1,437.00	1,084.00	1,218.00[a]	685.00	538.00
Average one-way commuting time per individual (minutes)	18.10	18.20	21.40	21.10	26.50	27.70
Total man-hours spent commuting per day	140.00	141.00	154.00	45.00	56.00	58.00
Average monetary cost of commuting to work per day	$ 3.50	$ 1.30[c]	$ 2.00	$3.59	$2.29	$3.62
Total monetary cost of assembling labor force per day	$ 812.00	$301.00	$466.00[d]	$230.00	$144.00	$232.00
Total value of worker's time spent commuting[b]	$ 214.00	$226.00	$247.00	$ 77.00	$ 97.00	$100.00
Total cost of assembling labor force	$1,026.00	$527.00	$713.00	$307.00	$240.00	$332.00

[a] Total vehicle miles differ from total passenger miles in Table 1, because of existing carpooling arrangements.
[b] Assumes that employee time spent commuting is valued at one-third of the wage rate (Manning).
[c] Average carpool mileage costs of 21 cents per mile were estimated.
[d] Average vanpool mileage costs of 43 cents per mile were estimated.

Time spent on the van routes for both plants ranged from 1 hour and 40 minutes to only 10 minutes for some of the in-town routes. The longest time route originated with an individual who lived 50 miles from work. Most of the routes generated utilized the full capacity of the 12-passenger van. However, two routes for Plant B consisted of only 2 and 5 passengers, the result of the extreme distances from work and unique location of these workers' residences. In reality, such individuals probably would not be allowed to participate in a van pool program; however, all individuals were included for the purposes of this study. The average one-way commuting times for Plants' A and B van pool participants were an estimated 21.4 and 27.7 minutes, respectively (Table 2). Therefore, van pool commuting time does not appear to be a potential shortcoming of the system, when compared with the current mode of transportation.

Van pooling, like the car pool system, would significantly reduce the total mileage required to assemble the work force. Plants A and B van pooling total passenger miles of 1,084 and 538 miles, respectively, were 75 and 56 percent less than that required by the current mode of transportation.

Van pool per-worker commuting costs of $2.00 and $3.62 per day for employees in Plants A and B, respectively, were higher than that of the car pool, but in the case of Plant A, were considerably less than current costs to the worker (Table 2). However, van pool costs of Plant B were higher than the estimated current cost. The total monetary cost of assembling Plant A's work force would be $466 daily, 43 percent lower than current costs. The total monetary cost of assembling Plant B's work force under the van pool system ($232) would exceed the current costs ($230) by only two dollars.

Of the three transportation modes considered, the van pool system incurred the largest cost in terms of time lost in commuting. Values of $247 and $100 were attributed to time spent going to and from work for Plants A and B, respectively. Plant A's overall total cost of the van pool system would be $713 per day, or a daily savings of about 30 percent. The total cost for Plant B exceeded the current daily costs by $25. Cost differences between Plants A and B were again attributed to differences in worker population density and worker numbers.

SUMMARY

This study examined the current journey-to-work characteristics of three rural Mississippi industrial plants. The costs of the current mode of transportation, which was predominantly single passenger automobiles, were estimated. For two of the three plants, two alternative modes of transportation were examined: car pools and van pools.

Results showed that in both Plants A and B, car pooling would reduce the workers' daily cost of transportation; however, van pooling would produce mixed results. The estimated van pool costs for Plant A were higher than those for car pooling, but still were substantially less than the current mode of transportation. Alternatively, the cost of a van pool system for Plant B was higher than the costs currently incurred by the workers.

A comparison of the car pool and van pool costs for Plants A and B showed the costs for Plant A to be consistently lower. The lower costs for Plant A were attributed to the larger work force, 232 compared to 64 for Plant B, and the higher work force population density. These factors contributed favorably to the formation of shorter, more efficient routes.

These research findings show that rural areas do have an alternative to the single-rider automobile. Car pools and van pools were shown to be economically viable alternatives in some instances. The level of cost savings and, consequently, the attractiveness of car pools and van pools to the worker will depend to a large degree upon the population density of the work force.

This research has looked at single plant scenarios. The feasibility of van pools and bus systems could be enhanced if several plants were located in close proximity of one another (e.g., in industrial parks). Further research evaluating the potential for these types of systems should prove beneficial.

Future research should also be focused on the logistical, institutional, and personal problems that would be encountered in trying to establish wide-scale car pooling and van pooling schemes. Also, it would be useful for those planning to implement such systems to understand worker attitudes toward such systems.

REFERENCES

Bureau of Economic Analysis. "Current Business Statistics," *Survey of Current Business* 60(1980).

Hallberg, M. C. and W. R. Kriebel. *Designing Efficient Pickup and Delivery Route Systems by Computer*. Pennsylvania State University, Bull. 782, June 1972.

Manning, Ian. *The Journey to Work*. Sidney: George Allen and Irwin, 1978.

Margolin, Joseph B. and Marion Ruth Misch. "Incentives and Disincentives for Ridesharing: A Behavioral Study." Federal Highway Administration, U.S. Department of Transportation, August 1978.

Tweeten, Luther and George L. Brinkman. *Micropolitan Development: Theory and Practice of Greater Rural Economic Development.* Ames: The Iowa State University Press, 1976.

U.S. Bureau of the Census. "The Journey to Work in the United States: 1975." *Current Population Reports,* Special Studies P-23, No. 99, July 1979.

U.S. Department of Energy. *Vanpool Implementation Handbook,* DOE/CS-0080, April 1979.

U.S. Department of Transportation. "Cost of Owning and Operating an Automobile." Federal Highway Administration, Washington, D.C. Issues for 1968, 1970, 1972, 1974, 1976, 1979.

Webb, Shwu-Eng, Gerald A. Doeksen, and Robert Carroll. "A Community Development Guide for a Transportation System for the Elderly." Oklahoma State University, Stillwater, Preliminary Report AE-8024, February 1980.