The Demand for Personal Travel in Developing Countries: An Empirical Analysis

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ABSTRACT

Conventional travel survey data, whether household- or traveler-based, are scarce in developing countries, and it is suggested that household expenditure surveys, which are relatively common, be used instead. Although many of the traditional topics of travel surveys cannot be addressed with expenditure data, many others can, and there are compensating advantages of coverage and scope. This concept is illustrated with data from household surveys of Sri Lanka, Hong Kong, Thailand, and Tunisia. Broad regularities in travel expenditures are discussed, both within and across countries, and for the Tunisian survey, a more detailed regression analysis is presented that focuses on the interrelations between travel expenditures and vehicle ownership.

A preliminary empirical analysis of the demand for personal travel in a number of developing countries is presented. The data come from household expenditure surveys and typically were not collected with the specific purpose of analyzing travel behavior. They are therefore inferior in many respects to standard travel surveys, which typically contain a great deal of "physical" (as opposed to financial) information about travel, for example, the number, length, frequency, and timing of trips for various purposes. However, by giving up this detail, several advantages are gained. Household expenditure surveys are relatively plentiful around the world. Most countries publish cost-of-living or other price index statistics, and household surveys are the standard way of obtaining the weights for their construction. The quality of design and data processing is often excellent; response rates are high by western standards, as is the quality of the interviewing and coding staff. The surveys are typically large and are representative of the country as a whole. Their size means that there is a great deal of useful data, and quantity is to some extent a substitute for lack of detail. However, representativeness is even more important. The choice-based sampling problem that arises from surveys confined to travelers is avoided, and information is given not only for urban areas, where a good deal is known about travel patterns in less-developed countries (LDCs), but also for rural areas for which there is much less information.

Studies such as those by Maunder (1-3), Eastman and Pickering (4), Heraty (5), and Thobani (6) have revealed much about trip patterns of household members in a number of urban contexts in developing countries, but research on personal travel in the countryside has been hampered by the lack of an adequate framework for description. In towns, trips can be conveniently classified by purpose; in LDCs they are usually to work or to school. They are regular, usually occurring 6 days a week, and they are predominantly single-purpose. None of these descriptions fits rural travel patterns, so that even the taxonomic framework around which a questionnaire could be designed is lacking. Expenditure surveys avoid these problems by asking much simpler and more limited questions, so although they cannot answer many of the questions to which answers are desired, they can tell a great deal about such matters as what fraction of households spends anything on travel at all, whether travel expenditures form a significant enough share of the budget to be worth investigating, and which modes account for the expenditures that do exist. This paper is concerned with presenting some of such information and demonstrating its usefulness. Many of the standard patterns that appear in the studies of trip patterns in urban areas can be discerned in the expenditure data here, so the approach of this paper can be seen as complementary to that of the standard studies.

There are two main empirical sections to the paper. In the first, the broad patterns of travel behavior are characterized by using data from five surveys or sets of surveys. These come from Hong Kong in 1979-1980; Sri Lanka, 1980-1981; Tunisia, 1979-1980; Thailand, 1975-1976; and from several suburbs of Delhi, India, in 1979-1982. In the second section, the Tunisian data are subjected to a more detailed analysis of the influence on household travel patterns of regional, occupational, and family composition variables. The analysis is, at this stage, primarily designed to be descriptive but is also guided by its potential relevance to questions of how transportation services should best be priced. Modern pricing or tax and subsidy theory [see, for example, an overview by Atkinson and Stiglitz (7)] has evolved a set of pricing rules that depends both on the distribution of commodity demands and on their sensitivity to price. In particular, if the pricing authority has an interest in improving the distribution of real income and if this interest cannot be met by direct systems of taxes and subsidies (and in LDCs this is usually thought to be very difficult), then it will generally be desirable to tax highly those expenditures that are more heavily consumed by richer consumers and subsidize those that figure most prominently in the budgets of the poor. However, if different goods are differentially elastic to price changes, this must be allowed for, too, and it is typically undesirable on efficiency grounds to tax heavily those commodities that consumers will readily find substitutes for in response to price increases. Clearly then, a good deal of empirical evidence is required to assess alternative pricing schemes; much of this evidence can be provided by household survey data. In partic-

ular, the surveys provide an excellent picture of who gets what, so that the distributional effects of price policy can readily be seen. Descriptions of the relationship between household income and expenditures on the various travel modes give a national picture of the consequences for real income distribution of changes in transport pricing policies, and the relationships with other variables such as region and household demographics reveal the differential effects of policy in different regions or over different household types.

TRAVEL PATTERNS FROM HOUSEHOLD SURVEYS

Evidence from four household surveys is discussed in this section; all are standard socioeconomic surveys specializing in the detail of household expenditures. The surveys are the 1980-1981 socioeconomic and labor force survey of Sri Lanka, with a sample size of nearly 10,000 households; the 1975-1976 socioeconomic survey of the whole kingdom of Thailand, with 11,000 households (here a 10 percent random sample is used in order to minimize processing costs); the 1979-1980 household expenditure survey of Hong Kong, with over 4,000 households; and the 1979-1980 expenditure survey of Tunisia, with almost 6,000 households. These particular surveys were chosen because of their current accessibility, diversity, and relatively detailed information on travel expenditure by modes.

Table 1 lists the evidence on travel expenditures as a component in total consumer expenditure. In principle, the denominator is total expenditure on nondurable goods and services, and shares are calculated for each household and then averaged by using weights as necessary to reflect the sample design. Note that this is quite different from total consumer expenditure on travel expressed as a share of all consumer expenditure. This alternative concept is effectively a weighted average of individual shares with weights proportional to household total expenditure; the rich are therefore effectively overrepresented. As an example, the aggregate figures for Sri Lanka corresponding to those in the table are 5.0, 6.7, 4.5 and 2.0; the rich spend a higher proportion of their outlay on travel.

TABLE 1 Personal Travel Expenditure as Share of Total Outlay

Area	Percentage
Hong Kong, 1979-1980	
All	5.68
Hong Kong Island	5.32
Kowloon	4.61
New Kowloon	6.66
New Territories	5.85
Sri Lanka, 1980-1981	
All	3.2
Urban	4.4
Rural	3.1
Estates	1.7
Tunisia, 1979-1980	
All	3.06
Cities	4.22
Towns	2.23
Rural	2.96
Thailand, 1975-1976	
All	4.07
Cities	4.91
Towns	4.17
Rural	3.50
Delhi suburbs, 1979-1982[a]	
Nand nagri	11
Shakarpur	12
W. Patel Nagar	11
Dakshin puri	8
Janakpuri	9
Saket	12

[a] As shares of income, not total outlay.

Delhi apart, there is a good deal of uniformity in these figures. Shares tend to be higher the higher the level of development and are higher in urban than in rural areas. Nevertheless, travel expenditures still exist in the countryside; even if a high proportion of trips are made by foot, and even in the (presumed) absence of regular commutation trips, the rural shares of expenditure are only 20 to 30 percent lower than those in the cities. Even in the extremely low-income tea estates of Sri Lanka, where incomes are barely above subsistence by most criteria, more than 1 1/2 percent of the budget is devoted to personal travel. The very high Indian figures, taken from work by Maunder (1), may be peculiar to Delhi where urban resettlement to relatively distant suburbs enforces high travel costs on even poor consumers. There may also be understatement of income, which would artificially inflate the ratios.

An alternative way of assessing the importance of travel expenditure is to examine the fraction of households spending nothing on travel. These ratios, corresponding to those in Table 1, are given in Table 2. Because surveys have a finite reporting period, these figures will be somewhat of an overestimate because occasional trips will only show up for a fraction of households. Nevertheless, the pattern is consistent with that in Table 1. Travel expenditure is a part of the budget for the vast majority of urban dwellers, and even in the rural areas, only a minority of households show no such expenditures. If Tables 1 and 2 are taken together, shares of the budget devoted to travel for households that spend something on travel can be calculated. By this measure, travel composes much the same share of travelers' budgets in the rural areas as it does in the cities and towns.

TABLE 2 Proportions of Households Reporting No Expenditures on Travel

Area	Percentage
Hong Kong	
All	3.02
Hong Kong Island	1.93
Kowloon	6.22
New Kowloon	1.69
New Territories	2.97
Sri Lanka	
All	25.0
Urban	26.1
Rural	24.1
Estates	33.7
Tunisia	
All	35.2
Cities	18.6
Towns	47.9
Rural	36.0
Thailand	
All	21.8
Cities[a]	21.0
Towns	22.5
Rural	22.1

[a] Bangkok, 14.4.

These patterns must be disaggregated by rich and poor households if the distributional effects of transport policy are to be assessed. Because expenditure groups are not comparable across countries,

TABLE 3 Proportions of the Budget Devoted to Travel by Expenditure Groups: Four Countries

Group	Percentage of Population in Group	Percentage Spending Nothing on Travel	Mean Share
Thailand			
1	3.7	64.3	1.90
2	11.1	45.7	2.51
3	15.2	29.7	2.87
4	22.6	22.3	3.37
5	15.9	16.4	4.07
6	15.4	39.0	4.93
7	5.8	7.5	6.64
8	6.5	2.7	6.19
9	3.7	7.0	8.70
Hong Kong			
1	1.0	40.0	1.75
2	3.8	17.8	4.10
3	6.4	10.1	5.27
4	10.9	3.3	5.25
5	12.0	1.7	5.12
6	11.8	1.6	5.40
7	10.5	0.5	5.70
8	7.9	1.7	5.79
9	6.8	1.6	6.02
10	5.6	0.0	6.30
11	7.8	0.3	6.62
12	5.2	0.4	6.73
13	6.0	0.3	6.72
14	1.8	0.0	5.92
15	2.4	0.0	8.06
Tunisia			
1	2.7	72.2	2.14
2	9.0	57.0	2.20
3	13.3	44.0	2.55
4	13.9	39.7	2.68
5	11.4	34.6	2.74
6	9.8	28.8	3.36
7	14.8	25.1	3.17
8	9.2	23.4	3.65
9	5.3	16.9	3.85
10	5.6	16.7	4.35
11	2.2	7.5	6.00
12	2.8	14.5	5.14
Sri Lanka			
1	5.0	51.5	1.4
2	5.0	39.0	1.9
3	10.0	31.3	1.8
4	10.0	32.4	2.0
5	10.0	28.6	2.2
6	10.0	27.2	2.2
7	10.0	24.1	2.7
8	10.0	22.4	2.9
9	10.0	16.5	3.8
10	10.0	14.2	4.5
11	5.0	9.1	6.3
12	5.0	5.9	11.0

Table 3 shows expenditure groups for each country from poorest to richest together with the estimated proportions of the population in each group. The third column gives the proportion of households in the expenditure group spending nothing on travel and the fourth the estimated mean of shares within the group. In all cases, the proportion spending nothing on travel declines steadily with increasing total expenditure (except possibly among the very rich, whose expenditure on private transport is more irregular and therefore less likely to occur in the survey period). Among the very poor, more than half spend nothing on travel, so subsidizing travel can do little for them. Note, however, the possibility that for some consumers, travel expenditures may be necessary for them to earn anything at all. Low or zero travel expenditures among the poor could therefore reflect high unemployment and poor work opportunities in those groups. As total outlays increase, the share devoted to travel also increases in all four surveys. The overall expenditure elasticity of travel is therefore typically greater than unity; overall subsidization will therefore tend to proportionally favor the rich over the poor. Depending on the price elasticity, efficiency considerations may offset the undesirability of this situation. Assessing the balance requires more detailed analysis than is possible here.

In Maunder's work (1) on the Delhi suburbs, travel shares are rather different from those in Table 3. For all six suburbs, the fraction of income devoted to travel is remarkably constant over all income groups except the poorest, where the shares are extraordinarily high, with averages as high as 30 to 40 percent in three of the districts. However, it should be noted that there are very small numbers of households in the poorest groups in the Delhi surveys, and that these groups, almost by definition, contain an abnormal representation of individuals whose incomes are temporarily low. In consequence, if travel expenditures remain at their normal level while incomes fluctuate, there will always be a few individuals or households with extremely large shares of income devoted to travel. This is no more a matter of concern than is the fact that a daily commuter who gets paid only weekly spends an infinitesimal fraction of his Monday's income on Monday's transport. Because total expenditures are much more stable than are incomes, this phenomenon is much less pronounced if shares of the budget are used in place of shares of income. Nevertheless, and in spite of the averages in Table 3, it is still the case that some poor households spend remarkably high proportions of their budgets on travel and that a higher proportion of poor households do so than is the case among groups that are better off, though not among the richest. For example, in Hong Kong, among the poorest 15 percent of the population, 14 percent spend more than 10 percent of their outlay on travel; in the next richest 25 percent, only 8 percent spend more than 10 percent. In Tunisia, of the poorest 15 percent, 6 percent spend more than 10 percent; the same is true of the next 15 percent in spite of their higher total budgets.

As is to be expected, modal choice shows much greater diversity across space than do the aggregate travel expenditure patterns. Tables 4-6 give the travel expenditure shares disaggregated by mode for Tunisia, Thailand, Hong Kong, and Sri Lanka. At this level of aggregation, these figures hold few surprises. Buses are the major item of expenditure throughout; in Tunisia, the hire car element that dominates outside the cities is essentially a form of bus service. Vehicle ownership is most important in the cities, and operating expenses are closely linked to automobile and motorcycle ownership. More interesting is to disaggregate these figures further, both by income level and by region. However, cross-tabulation is too clumsy a tool for this, and it is necessary to summarize the patterns more succinctly. Regression analysis is one way of doing this, and the next section contains some illustrative results from the Tunisian survey.

REGRESSION ANALYSIS OF TUNISIAN TRAVEL PATTERNS

One immediate problem with the application of regression analysis to travel expenditures is that a large fraction of households report zero expenditures. To some extent, these zeroes reflect low

TABLE 4 Travel Budget Shares by Mode: Tunisia and Thailand

Mode	All	Cities	Towns	Rural
Tunisia				
Total	3.06	4.22	2.23	2.96
Private	0.92	1.88	0.78	0.48
Public	2.14	2.34	1.45	2.48
Bus	0.52	1.10	0.30	0.35
Hire automobile	1.19	0.42	0.87	1.83
Taxi	0.20	0.35	0.10	0.18
Other (including season tickets)	0.23	0.47	0.19	0.12
Automobile ownership	15.8	25.4	14.5	11.4
Thailand				
Total	4.07	4.91	4.17	3.50
Local	1.97	2.52	1.93	1.64
Bus	1.51	1.71	1.68	1.31
Taxi	0.07	0.20	0.01	0.02
Other	0.39	0.61	0.24	0.31
Nonlocal	1.06	1.01	0.92	1.16
Bus	0.76	0.56	0.69	0.92
Other	0.30	0.45	0.23	0.24
Private	1.04	1.38	1.32	0.71
Automobile ownership	4.3	9.1	4.3	1.4
Motorcycle ownership	11.3	18.1	11.3	7.1
Bicycle ownership	26.8	25.2	31.6	25.8

TABLE 5 Travel Budget Shares by Mode: Hong Kong

Mode	All	Hong Kong Island	Kowloon	New Kowloon	New Territories
Total	5.68	5.32	4.61	6.66	5.85
Public	5.19	4.77	4.22	6.12	5.40
Bus	3.13	2.70	2.27	3.82	3.90
Taxi	0.86	0.74	1.00	0.86	0.76
Air	0.07	0.11	0.07	0.05	0.02
Other	1.13	1.22	0.88	1.39	0.72
Private	0.49	0.55	0.39	0.54	0.45

TABLE 6 Travel Budget Shares by Mode: Sri Lanka

Mode	All	Urban	Rural	Estates
Total	3.2	4.4	3.1	1.7
Public	2.6	3.0	2.6	1.6
Bus	2.3	2.5	2.3	1.4
Taxi	0.1	0.2	0.1	0.1
Train	0.2	0.3	0.1	0.1
Other	0.0	0.0	0.0	0.0
Private	0.6	1.4	0.5	0.1

frequencies of purchase; if trips on a particular mode are taken once a month and the survey period is a week, then a quarter of the households will register four times their normal weekly expenditures and three-quarters will register nothing. It is clear in this case that the expected value of expenditures is correct, and for that reason, a regression with expenditure as the dependent variable will yield unbiased and consistent parameter estimates. More difficult to deal with are those zeroes that occur because the household never makes that type of expenditure, and presumably this is frequently the case for certain travel modes and occasionally even for all travel expenditures. Unfortunately, there is no way of telling these "genuine" zeroes from the "infrequent purchase" zeroes, and even if this problem could be solved, there is as yet no agreed-on technique for estimating such models that is feasible on anything other than small data sets (8-10). In this paper, for lack of anything better, ordinary least-squares regressions are reported, and these include all the observations, zero or nonzero. This has the advantage of preserving the same sample for all regressions so that regressions for subcategories of expenditures relate to the same households as does the regression for the sum. Coefficients then add up across regressions, allowing decomposition of totals. The parameters of such regressions can also be straightforwardly interpreted, at least under certain assumptions. The coefficient on an explanatory variable estimates the corresponding coefficient for households that purchase that particular category multiplied by the proportion of such households. Dividing by this proportion yields the conditional coefficient, so that the regression context corresponds exactly to that in the cross-tabulations where the mean shares are unconditional means (including zeroes) and the means conditional on traveling can be obtained by dividing by the proportion of travelers.

The final issue is how to allow for ownership of motor vehicles. Clearly, the short-run travel decisions of household members depend crucially on whether the household owns a motor vehicle. In the long run, of course, vehicle ownership is determined along with other consumption decisions. Formally, the following expressions can be written:

$$y_i = \underline{\beta}_1' \underline{x}_{1i} + \theta d_i + u_{1i} \quad (1)$$

$$d_i^* = \underline{\beta}_2' \underline{x}_{2i} + u_{2i} \quad (2)$$

$$d_i = 1 \quad \text{if } d_i^* \geq 0$$

$$= 0 \quad \text{if } d_i^* < 0 \quad (3)$$

where

u_1, u_2 = endowed with a joint distribution, usually bivariate normal;
y_i = expenditure by household i on some mode, say buses;
d_i = dummy variable that is 1 if a vehicle is owned and zero otherwise; and
$\underline{x}_1$ and $\underline{x}_2$ = vectors of variables influencing bus travel and vehicle ownership, respectively.

The estimation of this model is discussed, for example, by Heckman (11) and ideally is handled as follows. Equations 2 and 3, the vehicle ownership equations, are estimated by a standard probit. Equation 1 is then estimated by "instrumental variables" by replacing d_i by its estimated probability of being unity from the probit. For this to work properly, there must be variables in $\underline{x}_2$ that do not appear in $\underline{x}_1$; otherwise the model is essentially underidentified (except for functional form, which is a poor crutch on which to lean). For the current Tunisian data, the most plausible variables appear to be the employment status of heads of households. Presumably certain types of workers will need private means of transport, for example, those for whom there is a high penalty for persistently being late for work. Otherwise there appears little reason to expect household transport budget shares to depend directly on employment status.

One possibility that is followed here is to estimate Equation 1 as it stands; this produces consistent estimates only if u_1 and u_2 are independent, that is, only when there are no common omitted variables. If one could believe this, the estimates from Equation 1 could be regarded as those of short-run demands. The second line is to estimate Equation 1 excluding d_i; this can be thought of as a linearized reduced form or long-run demand. For example, condi-

tional on vehicle ownership, the income elasticity of the demand for bus tickets may be positive, whereas the long-run elasticity, taking into account higher vehicle ownership, may be negative.

Therefore the determinants of the probability of vehicle ownership are presented first. For convenience, the formulation used was logit rather than probit. Hence, the parameters shown in Table 7 represent the derivative with respect to each explanatory variable of the log odds in favor of owning an automobile.

TABLE 7 Vehicle-Ownership Logistic Regression: Tunisia

Variable	Abbreviation	Coefficient	Chi-Square
Regression constant	CONST	-2.71	281.8
Total household expenditure	THE	0.0004	173.6
No. of female workers	NFW	-0.96	1.9
No. of male workers	NMW	0.07	2.0
No. of children in primary school	NCP	0.04	1.3
No. of children in high school and tertiary education	NCH	-0.08	1.9
Cities			
Northeast	CNE	-0.68	18.5
Center	CC	-0.87	6.2
South	CS	1.45	62.5
Towns			
Northeast	TNE	-0.85	18.5
Northwest	TNW	-0.73	11.3
Center	TC	-0.78	19.9
South	TS	-0.36	4.0
Rural areas			
Northeast	RNE	-1.04	31.1
Northwest	RNW	-0.20	2.0
Center	RC	-1.08	42.4
Employer	PATRON	0.88	14.9
Self-employed	INDEP	0.48	9.2
Laborer	OUVRIER	0.57	15.4
Wage earner	EMPLOYEE	1.26	60.5
Salaried employee	SALARIE	0.75	1.3
Family worker	AIDEFAM	1.85	6.9

Note: The model was estimated without weighting the sample data. Model $\chi^2 = 675.73$; degrees of freedom = 21.

As is to be expected, the level of total household expenditure is the dominant explanatory variable. The coefficient suggests that an increase in total housing expenditure of 1,200 dinars, say for just below the first quartile to just above the third quartile, would raise the log odds by 0.53, and the probability of ownership from, say, 0.25 to 0.38. Additional male workers and primary school children have a positive effect on vehicle ownership; female workers and school children have negative coefficients. All of these effects, however, appear to be rather weak. The regional and urbanization dummies indicate that the probability of owning a vehicle is greatest in the south, especially in the cities. Adopting rural south as the base, the probability of ownership is slightly lower in the towns and significantly lower in the rural northeast and center. The concentration of private modes in the south presumably reflects a relative shortage of public transport in that region. The base for employment status of the head of the household incorporates persons not working and a small group of apprentices and persons for whom occupations are unknown, which accounts, in all, for about 16.5 percent of the sample. The probability of owning a vehicle is greater for all other groups and is surprisingly large for wage earners and family workers.

Tables 8 and 9 show what, with some presumption, are labeled short-run and long-run travel regressions; Table 8 contains the ownership dummy and Table 9 does not. The responses are not inconsistent with this basic interpretation. For example, Table 8 shows the total expenditure elasticities of the transport, private, and public categories to be (at the mean) 1.1, 1.3, and 1.0, respectively. In Table 9, when the long-run effects operating through vehicle ownership are also included, these become 1.3, 2.0, and 0.98, respectively. Because vehicle ownership itself responds to changes in per-capita household expenditures (PCEs), long-run elasticities are higher for those categories that are positively affected by vehicle ownership and lower for those that are negatively affected. Similar patterns of short-run versus long-run responses can be seen for the coefficient on the number of male workers in the household; once again, it is the strong effect on vehicle ownership that accounts for the differences in parameter estimates between Tables 8 and 9.

In reading these tables it is helpful to note that because total transport is the sum of the public and private categories, column 1 is the sum of columns 2 and 3. Similarly, public transport is the sum of five modes shown plus an unimportant "other" category so that column 3 is the sum of columns 4 through 8 approximately. Hence, looking along rows reveals how the structure (as well as total) of travel demand responds to changes in the variable concerned. Taking PCE first, it may be seen that better-off households spend a larger share of their outlay on travel, an increase that is almost totally in the short run and more than totally in the long run accounted for by the luxury nature of private travel expenditures. Among the public modes, taxis and car hiring tend to replace buses among better-off households, other things held constant. The next group of variables shows the impact of work and education patterns on travel expenditures. From Table 8, extra workers, male or female, have a similar effect on the public travel share, as do extra high school children. Primary school children have little impact on the budget, presumably because primary schools are relatively close to residences and therefore do not involve paid trips. Extra male workers, conditional on automobile ownership status, cause a switch from private to public transport; in the long run such workers tend to lead to higher probabilities of automobile ownership. These results are clearly consistent with fixed trip patterns in relation to work and higher education. The public modes associated with these trips are of some interest. The additional public share associated with male workers goes to buses and to hires, presumably the former in the towns and the latter in the countryside. Hires are also associated with extra female workers and high school children, but there is no effect on bus fares, only on season tickets. Presumably there is some explanation for this anomaly.

The regional dummies are of interest in assessing how much of the regional variations in patterns remain once the other variables, particularly PCE, have been controlled for. Notably, most of the variations in the share of private transport over regions and levels of urbanization are explained by the other variables, although there is still a significant positive dummy for southern cities. Otherwise, public transport tends to be low in the towns; the cities are heavy on buses and the rural areas on hiring, and neither is very important in the towns, hence the difference.

SUMMARY AND CONCLUSIONS

In this paper, it is proposed that household expenditure surveys be regarded as a useful supplementary source of data on household travel patterns and the point is illustrated with travel data from a number of household surveys from developing countries around

TABLE 8 Short-Run Travel Regression

Variable	Transport	Private	Public	Buses	Hires	Taxis	Seasons	Trains
CONST								
Coefficient	.54	−1.5	2.1	.48	1.4	.06	.09	−.004
t-Statistic	1.2	−5.5	5.3	2.5	4.7	0.7	1.0	−.04
LN PCE								
Coefficient	.33	.28	.05	−.06	.06	.04	−.01	.02
t-Statistic	4.1	5.8	0.8	1.9	1.1	2.8	−.9	1.3
NFW								
Coefficient	.20	.04	.16	−.01	.08	.01	.06	.01
t-Statistic	2.2	0.8	2.1	−0.1	1.3	.4	3.9	0.7
NMW								
Coefficient	.04	−.13	.17	.11	.09	−.003	−.001	−.03
t-Statistic	0.7	−3.5	3.2	4.5	2.2	−.3	−.13	−2.2
NCP								
Coefficient	−.06	.02	−.08	−.04	−.03	.01	−.01	−.01
t-Statistic	−1.2	0.8	−1.9	−2.3	−0.9	1.3	1.1	−0.9
NCH								
Coefficient	.20	−.01	.21	.03	.08	−.01	.13	−.01
t-Statistic	2.5	−0.2	3.1	0.9	1.4	−1.0	9.1	−0.6
MVD								
Coefficient	4.6	5.4	−.84	−.33	−.34	−.05	−.05	−.09
t-Statistic	28.1	56.0	−6.2	−5.0	−3.2	−1.5	−1.6	−2.3
CNE								
Coefficient	.41	.74	−.33	.72	−1.4	.07	.25	.12
t-Statistic	1.8	5.4	−1.7	7.8	−9.7	1.6	6.0	2.2
CC								
Coefficient	−.40	.11	−.51	1.1	−1.7	.07	−.07	.12
t-Statistic	−0.9	0.4	−1.3	6.1	−5.8	0.9	−0.9	1.2
CS								
Coefficient	.76	−.10	.87	1.8	−1.2	−.04	.05	.34
t-Statistic	2.4	−0.6	3.3	13.9	−5.9	−0.6	0.8	4.7
TNE								
Coefficient	−.89	.11	−.99	.22	−1.1	−.19	.15	−.02
t-Statistic	−3.2	0.7	−4.3	2.0	−6.1	−3.6	3.0	−0.4
TNW								
Coefficient	−1.3	.30	−1.6	−.20	−1.3	−.20	−.07	.25
t-Statistic	−4.0	1.6	−5.9	−1.6	−6.4	−3.3	−1.2	3.4
TC								
Coefficient	−.50	.21	−.71	.25	−.70	−.24	.03	−.01
t-Statistic	−2.0	1.4	−3.4	2.5	−4.2	−5.2	0.6	−0.2
TS								
Coefficient	−1.4	−.19	−1.2	−.002	−1.0	−.14	.003	−.01
t-Statistic	−5.3	−1.2	−5.4	−.02	−5.9	−2.9	.06	−0.1
RNE								
Coefficient	.61	.33	.28	.79	−.55	−.09	.10	.07
t-Statistic	2.4	2.1	1.3	7.6	−3.2	−1.8	2.0	1.2
RNW								
Coefficient	−1.0	−.13	−.91	−.26	−.50	−.12	−.03	.02
t-Statistic	−4.4	−0.9	−4.5	−2.7	−3.2	−2.6	−.6	0.3
RC								
Coefficient	.96	.42	.54	.02	.77	−.15	−.05	−.02
t-Statistic	4.1	3.0	2.8	0.2	5.1	−3.4	−1.1	−0.3

Note: All coefficients (times 100) express the shares in total expenditures of each mode. LNPCE = log of per-capita household expenditure; MVD = dummy (1) if vehicles owned. All other abbreviations are given in Table 7.

the world. The share of the budget devoted to travel appears to increase slightly with income within countries, and the limited evidence here reveals that the share also increases as does the level of development. Travel expenditures in relation to the total budget are greater in urban than in rural areas, though travel expenditures are still substantial in the latter. The vast majority of the households sampled, whether in Sri Lanka, Hong Kong, Thailand, or Tunisia, show some expenditure on travel. As with the share devoted to travel, the fraction of households spending anything on travel tends to increase with income in all the surveys. The pattern of mode choice is less uniform across surveys than is the broad characterization of total travel expenditures; as is to be expected, local availability exerts a strong influence on the details of transport modes. For the Tunisian data, the pattern of vehicle ownership was studied together with its relation to patterns of household expenditures on travel. Total household resources exercise the dominant influence on both, though other factors, such as the presence of additional male members in the household, are important for determining the probability of vehicle ownership. Travel expenditures themselves are significantly influenced by vehicle ownership, so that factors such as income exert quite different long- and short-run effects. In particular, conditional on vehicle ownership, both public and private transport are income elastic, but once the effects of income on promoting automobile ownership are allowed for, private transport becomes more elastic and the elasticity of demand for public transport falls below unity. As is to be expected, regional effects are strong, as are the influences of the demographic composition of the household. The latter are consistent with findings in other developing countries that the majority of

TABLE 9 Long-Run Travel Regression

Variable	Transport	Private	Public	Buses	Hires	Taxis	Seasons	Trains
CONST								
Coefficient	−1.6	−4.1	2.5	6.3	1.6	.08	.11	.04
t-Statistic	−3.3	−12.1	6.4	3.4	5.3	0.9	1.3	0.4
RNPCE								
Coefficient	0.86	.91	−.04	−.10	.02	.04	−.02	.01
t-Statistic	10.2	15.5	−.7	−3.1	0.3	2.6	−1.3	0.7
NFW								
Coefficient	.20	.04	.16	−.01	.08	.01	−.06	.01
t-Statistic	2.1	0.7	2.1	−0.2	1.3	0.4	3.9	0.6
NMW								
Coefficient	.18	.04	.14	.10	.08	−.005	−.003	−.03
t-Statistic	2.8	0.5	2.8	4.1	2.0	−0.4	−0.3	−2.4
NCP								
Coefficient	.05	.15	−.10	−.05	−.04	.01	−.01	−.01
t-Statistic	0.9	4.2	−2.4	−2.6	−1.1	1.1	−1.3	−1.1
NCH								
Coefficient	.21	0	.21	.03	.07	−.01	.13	−.01
t-Statistic	2.5	0.1	3.0	0.9	1.4	−1.0	9.1	−0.6
CNE								
Coefficient	.06	.32	−.27	.75	−1.4	.07	.25	.12
t-Statistic	0.2	1.9	−1.4	8.1	−9.5	1.7	6.1	2.4
CC								
Coefficient	−.94	−.53	−.41	1.2	−1.7	.08	−0.7	.13
t-Statistic	−2.0	−1.6	−1.1	6.3	−5.6	1.0	−0.8	1.3
CS								
Coefficient	2.2	1.6	.61	1.7	−1.3	−.05	.03	.31
t-Statistic	6.6	6.9	2.4	13.3	−6.5	−0.9	0.5	4.4
TNE								
Coefficient	−1.4	− .47	−.90	.25	−1.1	−.18	.16	−.01
t-Statistic	4.6	−2.3	−3.9	2.3	−5.9	−3.5	3.1	−0.2
TNW								
Coefficient	−1.6	−.14	−1.5	−.18	−1.3	−.19	−.06	.26
t-Statistic	−4.9	−0.6	−5.6	−1.4	−6.3	−3.2	−1.1	3.5
TC								
Coefficient	−.93	−.29	−.64	.28	−.67	−.24	.03	−.01
t-Statistic	−3.5	−1.6	−3.0	2.8	−4.1	−5.2	0.7	−0.1
TS								
Coefficient	−1.5	−.41	−1.2	.01	−1.0	−.14	.005	−.002
t-Statistic	−5.6	−2.1	−5.3	0.1	−5.8	−2.9	0.1	−0.03
RNE								
Coefficient	.16	−.21	.37	.83	−.52	−.08	.10	.08
t-Statistic	0.6	−1.1	1.7	8.0	−3.1	−1.7	2.1	1.4
RNW								
Coefficient	−1.0	−.09	−.92	−.26	−.50	−.12	−.03	.02
t-Statistic	−4.0	−0.5	−4.6	−2.7	−3.2	−2.6	−0.6	0.3
RC								
Coefficient	.56	−.06	.62	.05	.80	−.14	−.04	−.01
t-Statistic	2.3	−0.3	3.2	0.5	5.3	−3.3	−1.0	−0.2

Note: Coefficients (times 100) express the shares in total expenditures of each mode. Abbreviations are as given in Table 7.

household trips are associated with either work or school. Although not all such trips give rise to expenditures, the pattern of paid-for trips appears to be similar to that for all trips. These results appear to be of considerable interest in their own right and, in the author's view, they demonstrate the usefulness of household expenditure survey data for the analysis of travel behavior.

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Analysis of Automobile Ownership by Using a Divisive Hierarchical Technique

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ABSTRACT

A method of analysis of personal automobile ownership is presented that differs from the well-known aggregate and disaggregate methods. The analysis consists of two steps. First, a cluster-segmentation method is applied to data from the Dutch National Travel Survey. The results show that personal automobile ownership is mainly determined by personal net income, age, and sex. Second, a model has been specified that includes these factors. When income and age are accounted for, a structural difference in automobile ownership is shown between men and women. Furthermore, for the period studied (1979-1982) the results indicate that for the age group 65 and older, automobile ownership increased significantly, whereas for those 25 years and younger, it decreased. Advantages of the method are (a) the relative stability of the homogeneous population groups independent of accidental changes in the survey population and (b) insight into the relationship of automobile ownership with the most essential determining factors. Because of these advantages, the method presented can be used to improve both analysis and forecast of automobile ownership.

It has been widely recognized that travel behavior is strongly influenced by automobile ownership. This applies to mode choice as well as to trip frequency and daily mileage (1-3). Therefore numerous models of automobile ownership have been developed, both at aggregate and disaggregate levels (4). Some models are based on time-series data under the assumption that a certain saturation level exists, whereas others are disaggregate at the household level and are based on cross-sectional data (5,6). Because both aggregate and disaggregate methods suffer from a number of disadvantages (7-9), another method is applied in this paper.

Phase 1 of this work aims at finding those demographic and socioeconomic factors that influence personal automobile ownership most. The survey population is split into homogeneous population groups according to these most important factors. Personal automobile ownership is preferred here to household automobile ownership because models of travel behavior are usually specified at a personal level and because this analysis is part of a comprehensive transportation study. Phase 2 of this work focuses on the level of influence of these factors on automobile ownership and investigates trends in the development of automobile ownership in the homogeneous population groups.

DATA BASE

The data base used was Onderzoek Verplaatsingsgedrag (OVG), the Dutch National Travel Survey (10). It contains extensive information, both demographic and