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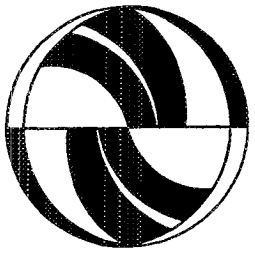

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Behavioral response to congestion: identifying patterns and socio-economic differences in adoption

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An understanding of how individuals perceive congestion and the range of coping strategies they adopt is crucial for the development of relevant, effective policies. This study empirically tested two hypotheses: (1) that responses to unsatisfactory conditions, such as a congested commute, are a function of previously adopted adjustments; and (2) that responses to congestion are distributed differently across various socio-economic segments. Coping strategies were classified into tiers according to their similarity in implementation cost and effort: lower-effort strategies which increase the comfort in maintaining existing travel patterns; moderate-effort strategies which tend to reduce travel; and major lifestyle/location change strategies such as job or residence changes. Findings confirm that lower-effort strategies tend to be adopted first, with higher-effort strategies adopted if dissatisfaction persists. The adoption of most types of strategies, especially the more costly ones, appears to fall disproportionately to women. Additionally differences were identified by family status, income level, employment status, and household type. These results illustrate the need for further study into patterns of behavioral response to congestion, with the goals of improving forecasts of the effects of congestion mitigation policies and identifying distributional inequities in those effects.

Keywords: behavior, congestion, coping strategies, socio-economic differences

Introduction

Congestion is a well-known problem for modern city dwellers, and a major issue on the public, and consequently the political, agenda. It imposes not just a personal cost but a major social cost. The value of time lost due to congestion in the United States is estimated at $48 billion per year (Arnott and Small, 1994). All else equal, congested traffic produces more air pollutants than smooth traffic flow and consumes more energy.

Much of the attention of transportation policy makers and planners is focused on means to alleviate congestion. Congestion is commonly seen as a result of the gap between the direct costs to the individual and externalities imposed by the individual on others. As individual costs do not account for the full social costs, drivers are inclined to behave in a manner which is socially undesirable. This discrepancy between individual and social costs as the underlying cause of congestion must be borne in mind when policy measures to curb congestion are devised. Such policies often assume that an individual will respond in a manner congruent with the social objective. Very likely however, individuals will respond in a manner which best suits them. For example, while congestion is increasingly recognized as a major urban problem, it may not necessarily result in deteriorating travel times for individuals (Gordon *et al.*, 1991; Levinson and Kumar, 1994). It is true that as cities and automobile dependence grow, congested traffic conditions persist for longer periods of time and on a growing geographical scale. However, individual commuters may adjust their behavior in a manner that does not result in increasing travel costs to them.

In a previous article, Salomon and Mokhtarian (1997) have addressed the gap between policy-makers' expectations and travellers' responses. It seems that in the face of increasing congestion, travellers adjust their behavior in ways which differ much from the responses expected by planners and policy-makers. Some eighteen responses identified as plausible personal adjustments, provide a useful perspective from which to assess policies designed to reduce congestion. The possible responses vary in their (generalized) cost of adoption and in their expected relief of the dissatisfaction associated with congestion.

Not only is the range of alternative adjustment strategies much wider than that commonly acknowledged by policy-makers, but it is also characterized by dynamics which result in diverse impacts on levels of dissatisfaction. The actual sequence of adjustments adopted by an individual is likely to be dependent on her or his previous experience.

Behavioral adjustments also differ in the distribution of costs and benefits, among the individual, household members, and society. Some adjustments entail only personal costs whereas others impose some costs on other household members. Consequently, understanding the distribution of costs and benefits seems to be of significant importance to the study of congestion mitigation policies.

Assuming that adjustment processes in fact involve the transfer of travel costs into other facets of life, we hypothesize that different market segments are likely to incur different shares of such reallocated costs. An obvious example is the withdrawal of women from the labor force if travel costs are too high, as they cannot always reallocate domestic responsibilities to others. Viewing the behavioral adjustments as a transfer of costs, either between different facets of one's lifestyle or between individuals within an household, implies that responses to policy measures are likely to have distributional effects. Some groups may be more likely than others to carry the burden of adjustments.

Thus, the objectives of this study were to test two hypotheses: (1) that responses to congestion are a function of previously adopted adjustments; and (2) that the adoption of congestion-reduction policies is distributed differently across various socio-economic segments of the population. This paper presents the empirical evidence used to test these two hypotheses. Further work is in progress to estimate models describing behavioral responses to congestion as a function of previously adopted strategies and other explanatory variables.

The remainder of this paper is divided into four sections: the next section describes the data set used in the study and provides background information on coping strategies; the third section discusses the methodology and results of testing the first hypothesis through the identification of response patterns; the fourth section provides similar elaboration on testing the second hypothesis through an examination of the distributional effects of responses; and the fifth section presents a final discussion and conclusions.

While congestion is experienced on many urban trips, both work-bound and others, the current paper focuses only on work trips. We assume that the range of behavioral responses is dependent on the trip purpose, and thus dealing with non-work trips calls for a separate analysis.

The data

Background and description of sample

An earlier paper (Mokhtarian and Salomon, 1994) presented a conceptual model of a decision-making process that is initiated when an individual is dissatisfied with one or more elements of her/his lifestyle. Key components in the decision-making process include (1) constraints or facilitators that, respectively, hinder a change or make it easier for one to occur; and (2) drives that act as motivators for an individual to consider or adopt a change to the current situation. Although constraints and facilitators aid the process of making a lifestyle change, it is the presence of drives that results in an active search for alternatives. For example, in the context of facing a congested commute, eliminating a constraint such as lowering the cost will not alone cause an alternative to be chosen. A drive, such as the desire to have more leisure or family time, is also necessary to generate a change.

As part of this conceptual model, a choice set of potential responses to one or more of five lifestyle-related drives (work, family, leisure, environmental ideology, and travel) was identified. A questionnaire was developed for the purpose (among others) of obtaining data on the adoption and consideration of these alternative responses. The data used in this study were collected via administration of the questionnaire in December 1992 to employees of the City of San Diego, California. The final data set contained 621 usable responses, including information on previous and potential adjustments to satisfy lifestyle drives; attitudes toward work, family, and commuting; and demographic data. A more detailed discussion of the survey, sampling frame, and previous results can be found in Mokhtarian and Salomon (1996).

Here, we describe the sample using five demographic variables of particular interest to the present study: family status, annual household income, employment status, household type, and gender. Table 1 summarizes the distribution of respondents on each of these variables.

The family status variable contained four categories that described household composition in terms of the number of adults and children present. For brevity, we will use the phrase 'two-adult' to mean two or more adults. A plurality of respondents (45%) lived in two-

Table 1 Sample distribution of key characteristics ($n = 621$)

Category	No.	Percent	Category	No.	Percent
Family status			*Employment status*		
Single	121	19%	Sole employed worker	218	35%
2+ adults, no children	276	45%	F/T with other HH workers	377	61%
1 adult, with children	20	3%	P/T with other HH workers	26	4%
2+ adults, with children	204	33%			
			Household type		
Income			One-adult	141	23%
Less than $15,000	5	0.8%	Two-adult (or more)	480	77%
$15,000–$34,999	111	18%			
$35,000–$54,999	193	31%	*Gender*		
$55,000–$74,999	141	23%	Female	328	53%
$75,000–$94,999	92	15%	Male	292	47%
$95,000 or more	70	11%	Missing	1	0.2%
Missing	9	1%			

adult households with no children. A third lived in two-adult households with children. About a fifth (19%) lived alone, and 3% were single adults living with children. Since the latter category was too small to subdivide by gender (there were only two single fathers in the sample), it was combined with the category containing two or more adults with children after experimentation determined that results did not differ materially between combining it or eliminating it entirely.

The highest percentage (31%) of respondents had annual household incomes between $35 000 and $54 999 per year. The five respondents having annual incomes less than $15 000 were combined with the next higher category in the analyses that follow. Employment status was divided into three categories, in which (1) the respondent was the sole employed household member (35%); (2) the respondent was employed full-time with other employed household members (61%); or (3) the respondent was employed part-time with other employed household members (4%). Household type, while similar to family status, segmented the sample by the number of adults in a household rather than by the presence of children. Nearly a quarter (23%) of the sample lived in single-adult households, with the remainder living in two-adult households. Lastly, the sample was fairly evenly split between females (53%) and males (47%).

Behavioral responses to congestion

In one section of the survey, respondents were asked to indicate which of 23 responses or adjustments to lifestyle drives they (1) 'have already done'; (2) 'have been considering'; or (3) 'have not seriously considered'. Eighteen of those alternatives could be considered responses to a travel drive, specifically the drive to reduce the personal impacts of congestion. It is these responses or coping strategies that constitute the focus of the present study. A commuter may adopt any number or combination of such strategies in response to an unsatisfactory condition. Table 2 provides a listing of these coping strategies, lettered and worded as they appeared in the survey, but ordered differently as explained in the following section.

It is necessary to point out that there are some inherent limitations in the use of these data (which were collected primarily for a study of telecommuting) for the present purpose. First, although some of the strategies in Table 2 (e.g. e, q, s) were worded to relate specifically to congestion, most of them can also be adopted in response to drives other than congestion, as noted in Mokhtarian and Salomon (1994). In the next stage of analysis, models of considering various strategies as a function of commute characteristics (including perceptions of congestion) will be formulated. These models will clarify the nature and strength of the relationship between congestion and the consideration of these strategies. Second, some of the questions did provide a time frame for the adoption of the action, but some did not, and even for those which did, the exact timing was not well-defined. For example, respondents were asked, "Within the last two years, have you moved your residence closer to your job?". There is little difference, from this research perspective, if it were two or three years ago, but there is a difference if it were last month or 23 months ago. This is because, with increasing congestion, the benefit delivered by a change will attenuate over time, so that the time since a change was made becomes an important explanatory variable of the likelihood of considering another change (Salomon and Mokhtarian, 1997). Such a resolution is lacking here. Nevertheless, it is believed that in the aggregate, the behavior observed in this sample has something meaningful to say about the collective response to congestion.

When analyzing the data used in this study, seven cases out of an original 628 were identified as missing 17 or more of the travel-related responses and were discarded. Of the remaining 621 cases only 46 were missing any data in the section on responses to lifestyle drives. The majority of these (36 or 78%) were missing only one out of the 18 travel-related responses; the remaining ten were missing between two and four responses. All of these missing data were recoded to the

most common response for that survey question, and 621 cases were retained in the final working database.

Identifying patterns of response

The coping strategies shown in Table 2 can be grouped according to several different characteristics. First, they differ temporally, with some that may be adopted in the short term, others that may be adopted at a longer range, and still others that may be adopted in a very long time frame. Secondly, the responses differ in their cost of adoption (monetary and non-monetary). In general, those with a shorter adoption time correspond to a lower total cost and those involving the longest time to adopt are the most costly.

Although the strategies were designed to reflect different levels of implementation cost or effort, it is unrealistic to expect each and every strategy to be tried in turn because (1) some strategies effectively preclude others; (2) several responses may accomplish roughly the same purpose; and (3) unknown constraints may prevent the adoption of some strategies. Thus, we want to identify groups or tiers of strategies having similar costs and/or that accomplish similar objectives. Once the strategies are classified into tiers, we can test the hypothesis that responses to congestion are a function of previously adopted adjustments. If this is true, we should see patterns of responses where lower-cost strategies or options are adopted first, followed by the adoption of successively higher-cost strategies. That is,

Table 2 Survey questions on lifestyle-driven responses

Statement: For each of the items listed below, please indicate whether you have (1) already made that choice; (2) been considering that choice; or (3) not seriously considered that choice.

		Rank based on adoption (*increasing freq. of Category 1 responses*)	Rank based on lack of consideration (*decreasing freq. of Category 3 responses*)	Combined final ranking (*based on sum of previous 2 ranks*)
a.	Buy a car stereo system	2	1	1
e	Within the past year: Change work trip departure time to avoid congestion	1	2	1
j.	Adopt flextime	3	3	3
i.	Hire someone to do house or yard work to save time	4	5	4
c.	Buy/lease a better car	7	4	5
d.	Buy/lease a more fuel efficient car	6	6	6
l.	Within the past year: Change means of travel to work (such as from driving alone to carpooling)	5	8	7
m	Buy a home computer to be used for work	8	7	8
o.	Telecommute from home (part or full time)	10	9	9
n.	Buy other equipment/services to help me work from home	9	11	10
t.	Within the past 2 years: Work part-time instead of full-time	11	14	11
k.	Adopt compressed work week (such as a '4/40' or '9/80' schedule)	15	10	11
v.	Within the past 2 years: Start a home-based business (or put more effort into an existing one)	13	13	13
b.	Acquire a cellular phone	14	12	13
s.	Move my home closer to the job I have now	12	17	15
q.	Change to a new job closer to my current residence	16	15	16
w.	Retire or stop working by choice	17	16	17
p.	Telecommute from a local work center (part or full time)	18	18	18
f.	Within the past year: Change work trip departure time for personal reasons	N/A[1]	N/A	N/A
g.	During the past 6 months: Work unpaid overtime	N/A	N/A	N/A
h	During the past 6 months: Take work home	N/A	N/A	N/A
r.	Within the past 2 years: Change to a new job at the same location as before	N/A	N/A	N/A
u.	Within the past 2 years: Work full-time instead of part-time	N/A	N/A	N/A

[1]The last five strategies are considered to be responses to lifestyle drives other than travel, and are not analyzed here

when higher-cost strategies are adopted by an individual, it should most often be the case that lower-cost strategies have already been adopted by that individual. To test this hypothesis the data were first grouped into tiers, responses for each tier were then studied, and the resulting patterns were identified.

Categorizing responses into tiers

Two different methods were used as a basis for developing a hierarchical structure of coping strategies. The first method used the actual responses to the survey questions to rank and group strategies. In the second method, a factor analysis of the responses was performed to identify tier groupings. In both cases, the methods were used to generate an initial structure which was then slightly modified judgmentally to achieve greater conceptual clarity.

Rank ordering. Rank ordering partitions the coping strategies into tiers based on the empirical frequency of their adoption and consideration. The assumption is that this frequency reflects the respondents' collective perceptions of the implementation cost or effort required for each group of strategies. Those strategies that 'have already been done' by the most people are those with relatively lower costs. Similarly, the strategies that were 'not seriously considered' by the fewest number of people should be those with relatively low implementation cost. Combining the rank orderings of those strategies that have been adopted the most often with those that have not been considered the least often provided a robust basis for constructing three tiers that reflect low, medium, and high implementation cost. Table 2 lists both the individual and final (combined) ranking scores for each survey question. The final rankings were then used to create a three-tier structuring of the coping strategies.

As shown in Table 3, each of the three tiers reflects a difference in implementation difficulty and cost, with Tier 1 composed of strategies that were adopted or considered the most frequently and Tier 3 containing strategies that were adopted or considered least often. Tier 1 strategies are short-term, low-cost, strategies referred to as *travel-maintaining*. The purpose of Tier 1 strategies is to *reduce the cost of traveling* (e.g. to make it more comfortable) *rather than to reduce the amount of travel itself.* By contrast, Tier 2 contains *travel-reducing* strategies that are medium-term and require a moderate implementation cost. Tier 3 strategies are

Table 3 Rank order and factor analysis tier structures

Tier description	Strategies	Cost	Term
Rank-based tiers			
1. Travel maintaining	Buy a car stereo system Change work trip departure time to avoid congestion Adopt flextime Hire someone to do house or yard work to save time Buy/lease a better car Buy/lease a more fuel efficient car Acquire a cellular phone	Low	Short
2. Travel reducing	Change means of travel to work Buy a home computer to be used for work Telecommute from home Buy other equipment/services to help me work from home Adopt compressed work week Telecommute from a local work center	Moderate	Medium
3. Major location/lifestyle change	Work part-time instead of full-time Start/enhance a home-based business Move my home closer to the job I have now Change to a new job closer to my current residence Retire or stop working by choice	High	Long
Factor-based tiers			
1. Auto improvement	Buy a car stereo system Acquire a cellular phone Buy/lease a better car	Low	Short
2. Departure time	Change work trip departure time to avoid congestion	Low–Moderate	Short
3. Work schedule change	Adopt flextime Adopt compressed work week	Moderate	Short
4. Remote work	Buy a home computer to be used for work Buy other equipment/services to help me work from home Telecommute from home Telecommute from a local work center	Moderate–High	Medium
5. Relocation	Change to a new job closer to my current residence Move my home closer to the job I have now	High	Long
6. Work/lifestyle change	Work part-time instead of full-time Start/enhance a home-based business Retire or stop working by choice	High	Long

major location/lifestyle changes that are implemented in the long-term and have the greatest expense.

In grouping strategies into the tiers, a few strategies were judgmentally moved into a tier different from that indicated by their empirical rank in order to create a better fit with tier characteristics. Option 'p', 'telecommute from a local work center, part- or full-time', received the lowest rank of all responses. Telecommuting from a local work center was not common when the data were collected in 1992. It could not have been chosen by many and is unlikely to have been considered or well-understood by survey respondents. However, availability aside, in terms of time frame and cost of implementation it resembles Tier 2 strategies more closely than Tier 3 strategies. For this reason, it was moved to the medium-term travel-reducing strategies of Tier 2, to reflect an expected outcome as working from a telecenter becomes more common.

Additionally, in summing the ranking scores there were three sets of ties, most importantly between the scores for strategies 't' and 'k' and between the following pair 'v' and 'b'. Based on the characteristics of other responses in each tier, options 't' ('work part-time instead of full-time') and 'v' ('start a home-based business or put more effort into an existing one') were assigned to Tier 3 whereas option 'k' ('adopt compressed work week') was assigned to Tier 2. Option 'b' ('acquire a cellular phone') was assigned to Tier 1. The empirical ranking of option 'b' was again assumed to be a consequence of the relative unavailability of cellular phones in 1992. As expense falls and coverage rises, it is more appropriately considered a Tier 1 strategy.

It should also be noted that strategy 'i', 'hire someone to do house or yard work to save time', is somewhat different in nature from the other options in Tier 1. However, because it allows time to be spent on existing travel, by having others take on house or yard work, rather than reducing travel time so that respondents could spend that time on domestic work themselves, it was retained with the other travel-maintaining options.

Factor analysis. A factor analysis of the survey data was also conducted to group those responses with common patterns of variation across the sample. The scree plot from an unrotated factor solution matrix was examined to suggest the number of factors needed, and three-, four-, five-, and six-factor solutions were created using principal axis factoring and varimax rotation methods. The five-factor solution provided the most interpretable results and was used as a basis for the six-tier structure presented in Table 3. The results, shown in Table 3, also separated the strategies, fairly distinctly, by type: (1) auto improvement; (2) departure time; (3) work schedule change; (4) remote work: (5) relocation; and (6) work/lifestyle change.

The Tier 1 elements of the six-tier factor-based structure are short-term, low-cost, auto improvement strategies. Tier 2 contains the low-to-moderate-cost, short-term strategy 'e', 'change work trip departure time to avoid congestion'. Although this strategy ranked number one in adoption, collectively strategies 'a', 'b', and 'c' of Tier 1 had a greater percentage of adoption (58.9%) than strategy 'e' alone (51.2%). This suggests that Tier 2 represents at least a slightly higher-cost strategy than Tier 1, which is plausible in view of the fact that, unlike Tier 1 strategies, adoption of Tier 2 may necessitate the reallocation of household assignments. The purpose of both Tier 1 and Tier 2 strategies is to reduce the *cost* of traveling (e.g. to make it more comfortable or less stressful).

The more costly work schedule strategies of Tier 3, 'adopt flextime' or 'adopt compressed work week', differ from Tier 2's 'change work trip departure time' in their perceived commitment level and availability at the work place (as well as in their potential impact on the household). Both flextime and compressed work week schedules are formalized arrangements that may require managerial approval or company existence of these programs, whereas changing work trip departure time can be adopted on an ad hoc basis. Nevertheless, assuming the existence of these programs in the organization, they can be adopted by the individual quite quickly. The remote work elements of Tier 4 also require formal programs or managerial approval, and are likely to be less readily available or easy to implement than work schedule changes. The impacts on the household may be stronger as well. Hence Tier 4 is arguably somewhat farther along the scales of both implementation cost and term than Tier 3. Nevertheless, both Tiers 3 and 4 contain strategies that have the potential to reduce the *amount* of travel (with the exception of strategy 'j', 'adopt flextime'). The strategies of Tiers 5 and 6 combined recreate the most costly tier of the three-tier rank-based structure. They involve relocation and work lifestyle changes that are both very high in cost and require long-term implementation, and were judged to be of equal difficulty in adoption.

Similarly to the creation of the rank-based tier structure, several strategies were eliminated from the tier indicated by their factor loadings or moved to another factor, to create a better fit with tier characteristics. Because option 'i', 'hire someone to do house or yard work to save time', loaded oddly on Tier 5 (work/lifestyle changes), and it, along with option 'd', 'buy/lease a more fuel efficient car', had weak connections as direct responses to a congested commute, they were eliminated. Responses to option 'l', 'change means of travel to work (such as from driving alone to carpooling)', were ambiguous as to the direction in which the mode change occurred, and so it too was eliminated here. All three strategies will be examined in the modeling phase of the project to assess the extent to which congestion contributes to their consideration by a respondent.

Two options were moved to different factors: option

'p' (telecommute from a local work center) loaded with the relocation strategies but was moved to the remote work factor, and option 'v' (start/enhance a home-based business) loaded weakly on the relocation factor but was moved to the work/lifestyle factor. Finally, option 'e' (change work trip departure time), which loaded with options 'j' and 'k' (adopt flextime and compressed work week), was placed in a separate tier for the reasons discussed above (i.e. differences in implementation cost).

Comments. Both the ranking and factor analysis methods resulted in similar tier structures with the most costly tiers identified by both methods being identical after minor adjustments (containing options q, s, t, v, and w). As with the three-tier rank-based structure, each of the six factor-based tiers represents a difference in implementation difficulty and cost. Both sets of tier structures are useful. From a policy analysis perspective, categorizing on the basis of travel impacts (maintaining travel, reducing travel, altering home-work locations), as the three-tier structure explicitly does, makes sense. However, the six-tier structure, based on conceptual similarities among strategies, may more closely reflect the bundles of strategies as they are perceived by individuals. Strategies within a given bundle represent, for the most part, alternative ways of accomplishing the same objective, and an individual is likely to select just one of them at a time. The six-tier structure also offers a more finely-grained assessment of implementation cost and term. For example, Tier 1 of the three-tier structure groups auto improvement strategies together with some of the schedule change strategies, creating an overall low-cost, short-term tier. The six-tier structure, however, separates these strategies and recognizes the higher total cost of changing work trip departure time or adopting flextime compared with making auto improvements. For both of these reasons, the six-tier structure may constitute a stronger basis for evaluating distributional impacts.

Because the main focus of this study is on understanding the patterns and distributional impacts of adoption, we adopted the factor-based six-tier structure for the distributional analyses of the following section after preliminary exploration suggested that substantively similar results would be obtained with both methods. With the tier structure in place, the next step is to examine whether patterns of response are consistent with the hypothesized ordering of lower-cost strategies being adopted first, followed by successively higher-cost strategies.

Testing the hypothesis of ordered response patterns

It is hypothesized that when faced with an unsatisfactory condition such as a congested commute, and motivated to make a change, individuals will adopt strategies in an ordered pattern. It is hypothesized that they will adopt the lower-cost, shorter-term, travel-maintaining strategies first, and then if the unsatisfactory condition persists, adopt successively higher-cost and longer-term strategies that not only reduce travel, but may eventually result in a major location/lifestyle change.

Note that by construction, lower-cost tiers will be adopted more often than higher-cost tiers, and hence a hypothesis which simply restates that idea would be tautological. Note also that tiers could be adopted at different rates, but still independently of each other. That is, a more costly tier could be adopted less often than a lower tier, but equally less often regardless of whether lower tiers had been adopted or not. We are hypothesizing that adoption is *not* independent, i.e. that an individual is more likely to adopt a higher-order tier if lower-order tiers have already been adopted than if they have not been adopted. That behavioral pattern, while plausible, is legitimately subject to test, and would, if true, have important implications for forecasting the response to congestion-reduction policies. This section develops a method for identifying patterns of response and then tests the level of compliance of respondents in the sample data with the hypothesized ordering.

Patterns of response. To test whether adoption of responses followed a sequential ordering (lower to higher cost), a binary variable was created for each of the six factor-based tiers. The idea is to set the variable corresponding to each tier equal to '1' if that tier can be considered to have been adopted; the question is what criterion for adoption to use. As mentioned earlier, selection of one strategy may effectively preclude others (especially others within the same tier) from being chosen, and several strategies within a given tier may be approximately interchangeable. For example, in Tier 5 option 'q' ('change to a new job closer to my current residence') and option 's' ('move my home closer to the job I have now') are similar strategies that accomplish roughly the same thing. It would not be reasonable to require both strategies to have been adopted in order to consider that tier implemented by a respondent. This is especially true of the more costly strategies of the last three tiers.

Because of these considerations, the variable corresponding to each tier was assigned a '1' if the respondent had 'already done' at least one of the strategies within that tier. If no strategy within that tier had been adopted, the variable was set equal to '0'. Further, for this part of the analysis, Tiers 3 and 4 and Tiers 5 and 6 were combined. The basis for doing so was that each member of the pair was of approximately equal implementation cost and somewhat interchangeable with the other member (adopting a strategy in one tier of the pair made it rather unlikely that a strategy in the other tier would also be adopted in the same time frame). Even though Tier 4 was argued to be farther along the implementation cost and term

scales than Tier 3, there is some evidence that schedule change and telecommuting options are seen as somewhat interchangeable ways of reducing the number of weekly commute trips. In fact some organizations explicitly prohibit an employee from engaging in both telecommuting and compressed work week schedules at the same time (Pratt, 1991).

Hence, the variables for all six tiers were combined into a sequence of four ones and zeros for each case that indicated the order and pattern of responses. For example, respondents who had adopted a Tier 1 and either a Tier 3 or 4 strategy, but not a Tier 2, 5, or 6 strategy, would have a '1010' response pattern. There were 2^4 or 16 possible response patterns of '1's and '0's.

Level of compliance. Some patterns of adoption (e.g. '1111', indicating the adoption of a strategy in each tier) unambiguously comply with the hypothesis. For those patterns that do not, degrees of compliance can be distinguished. A measure of the lack of compliance of response patterns to the hypothesis was developed as follows. Taking the approach that a violation in a higher tier is a more serious breach of the hypothesis than a lower-tier violation, each pattern was assigned a penalty of 'i' points for an 'incorrect' zero in the *ith* position, where 'incorrect' means skipping a lower-cost tier to adopt a higher-tier strategy. For example, a pattern of '0001' for the six tiers would receive six penalty points for having 'incorrect' zeros in the first (one point), second (two points), and third (three points) positions. A pattern of '1100' would receive no penalty points because it follows the hypothesized order of adopting lower-tier strategies before higher-tier ones.

Figure 1 shows the observed and expected responses for each level of compliance score for the six-tier solution. The expected number of responses corresponding to each level of compliance is obtained (under the null hypothesis of independence) by multiplying the marginal probabilities of adoption or non-adoption of each tier and the total sample size. For example, the expected number of people exhibiting the pattern '1100' is $0{\cdot}589\times0{\cdot}512\times0{\cdot}451\times0{\cdot}781\times621=66$, where the four proportions in the product are the estimated marginal probabilities of adopting Tiers 1 and 2 and not adopting Tiers 3, 4, 5, or 6, respectively (see Table 4 which tabulates the percentage of respondents adopting, as well as considering, each tier).

As seen, 54% of the respondents (334 out of 621) are observed to follow the hypothesized ordering exactly, whereas only 44% (276) are expected to do so under the null hypothesis of independence. An additional 17% violated the hypothesis only in skipping the lowest-cost tier, and 11% skipped just the second tier.

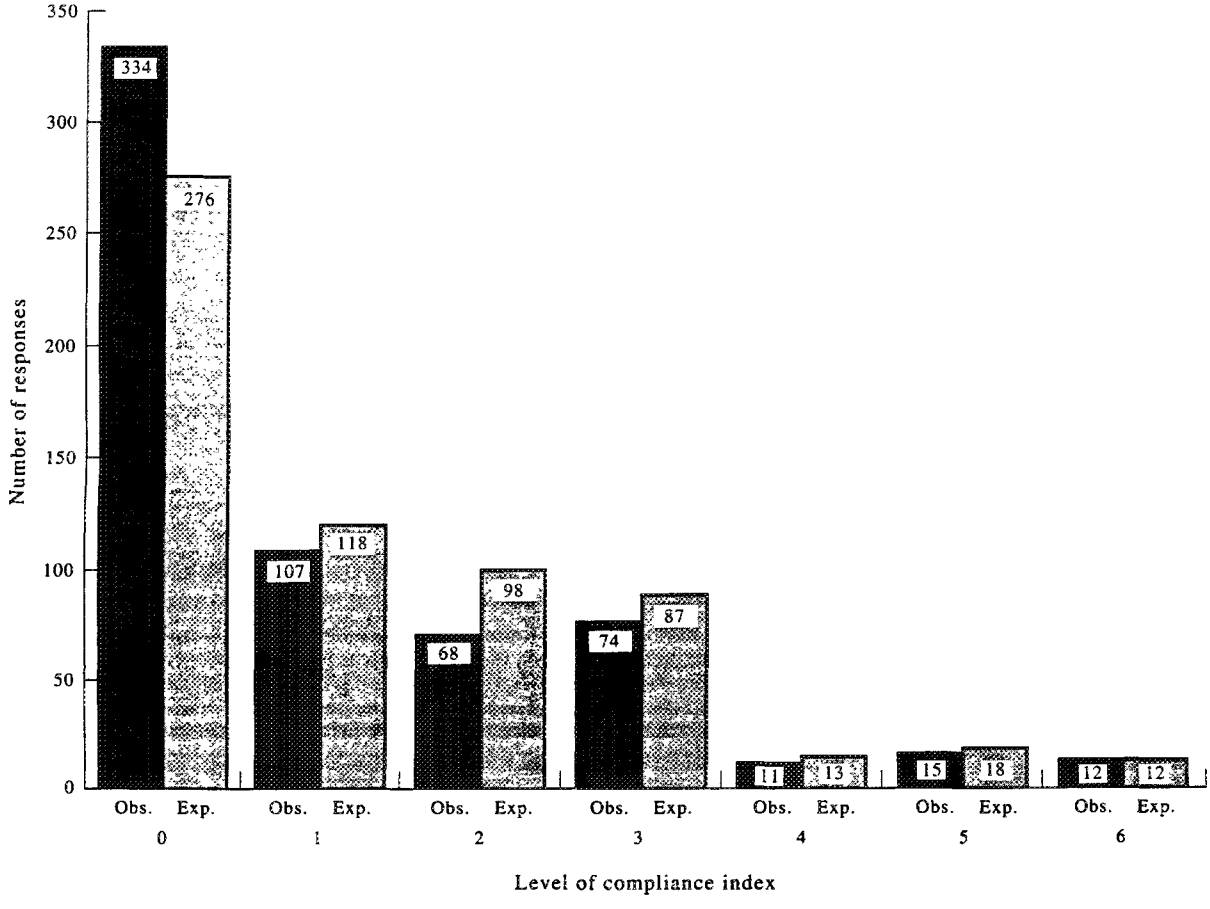

Figure 1 Observed and expected responses for each level of compliance: six-tier solution.

Table 4 Adoption and consideration of tiers

	Percent adopting	Percent considering
Rank-based tiers		
1	88.4	62.8
2	52.8	58.8
3	21.9	38.0
Factor-based tiers		
1	58.9	43.8
2	51.2	7.6
3	39.0	38.6
4	31.6	42 7
5	9.2	16.7
6	13.7	30.3
3 and/or 4	54.9	59.4
5 and/or 6	21.9	38.0

The procedure was also repeated for the rank-based three-tier structure, which had eight possible patterns, with similar results as shown in Figure 2. Compliance scores of '0' and '1' represented 92% of the cases. It should be noted that the more detailed six-tier structure will naturally have a lower percentage of compliance than the three-tier structure as it would be easier to skip tiers with a smaller number of strategies. Further, with smaller tiers it is more likely that all the strategies of some tiers (e.g. both flextime and compressed work week) would not be available to the respondent.

A chi-squared test can be conducted to test the null hypothesis that tiers are adopted independently of each other. Since we are testing for the independence of each dimension of a $2\times2\times2\times2$ contingency table (two levels for each of the four tiers or tier combinations), the degrees of freedom for the test are calculated as the number of parameters in the saturated log-linear model (16) minus the number in the independence model (5), i.e. 11 (Christensen, 1990).

The test statistic for the six-tier structure is computed to be 46·31, which results in rejecting the null hypothesis at $p=0.000$. Thus, we statistically reject the hypothesis that tiers are adopted independently. For the three-tier structure the degrees of freedom are 4 and the calculated chi-squared test statistic is 11.86, which also results in rejecting the hypothesis that the tiers are adopted independently at $p=0.018$.

It is possible to estimate log-linear models to identify more precisely the relationship among the various tiers. However, the main point is that, in keeping with the hypothesis of this study, adoption of each tier is not independent of the others. From Figure 1 and 2 we observe qualitatively that the dependence takes the expected form: specifically, respondents are more likely to adopt tiers in the order of lowest to highest cost than would be expected under the independence hypothesis.

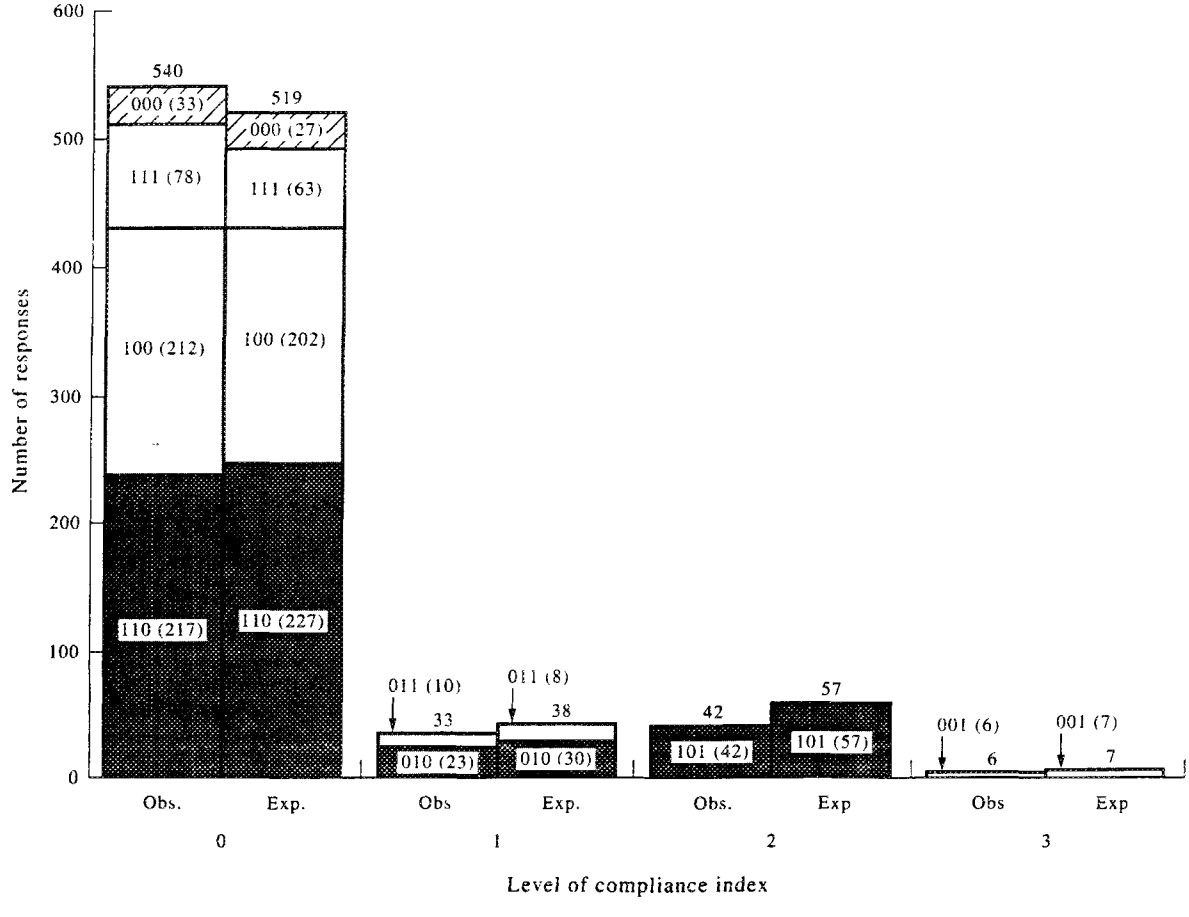

Figure 2 Observed and expected responses for each level of compliance: three-tier solution.

Distributional effects of responses

Methodology

The second hypothesis of this study is that the adoption (and consideration) of congestion-reduction strategies is distributed differently across various socio-economic segments of the population. To test this hypothesis, the binary tier adoption variables described previously in the subsection "Testing the Hypothesis of Ordered Response Patterns" were used (for the six-tier structure), and similar binary variables were created for having considered each tier. That is, the consideration variable for a given tier was set equal to one if the respondent had seriously considered at least one strategy in the tier. Table 4 presents the percentage of respondents who adopted and considered each tier.

Each tier variable was cross-tabulated with the demographic variables presented in Table 1: family status; income level; employment status; household type; and gender. Chi-squared tests of independence were performed to identify whether differences existed in the adoption or consideration of coping strategies between the subgroups of each demographic variable. Table 5 summarizes the results and describes the significant differences between subgroups for the adoption of strategies. Because there were relatively few significant results for the consideration variables they are not presented in tabular form here. They are mentioned, where appropriate, in the text. Table 5 presents the tier number and socio-economic variable for which the difference occurred, the p-value associated with each difference, and an interpretation of the results. In particular, the interpretation of results provides the percentage of respondents in the base category who chose the tier, and the probability ratio of adoption for that base category against each other subgroup within the variable. The significance of the difference is indicated by the number of asterisks on the probability ratio, as described in the table footnote. For example, 45% of the females in the sample adopted a Tier 3 strategy; females were 1.4 times as likely as males to do so, and the difference is significant at a p-value < 0.01.

Further comparisons were made through subdividing each demographic subgroup by gender. Where the previous tests identified differences across the subgroups within each variable, these chi-squared tests identified whether there were significant differences

Table 5 Socio-economic differences in the adoption of coping strategies

Demographic variables (sample size)	Tier 1 (a, b, c)	Tier 2 (e)	Tier 3 (j, k)	Tier 4 (m, n, o, p)	Tier 5 (q, s)	Tier 6 (t, v, w)
			Percent of base category choosing Probability ratio of base category to others			
Gender						
1. Female (328)		58% of females	45% of females		11% of females	18% of females
2. Male (292)		1.3×males***	1.4×males***		1.5×males*	1.9×males***
Family status						
1. Single (121)		55% of group 2		23% of group 1	16% of group 1	
2. 2+ adults, no children (276)		1.3×group 1 1.1×group 3*		0.69×group 2 0.69×group 3*	1.9×group 2 2.3×group 3**	
3. 1+ adult(s), with children (224)						
Income						
1. $0–$34 999 (116)	73% of group 5	45% of group 2		40% of group 5	5% of groups	22% of group 1
2. $35 000–$54 999 (193)	1.7×group 1 1.2×group 2	0.82×group 1 0.75×group 3		2.0×group 1 1.3×group 2	3, 4, 5 combined 0.36×group 1	1.8×group 2 2.3×group 3
3. $55 000–$74 999 (141)	1.2×group 3 1.2×group	0.96×group 4 0.89×group 5*		1.2×group 3 1.1×group 4**	0.33×group 2***	1.4×group 4 1.5×group 5*
4. $75 000–$94 999 (92)	4***					
5. $95 000 or more (70)						
Employment status						
1. Sole employed worker (218)			54% of group 3 1.6×group 1			77% of group 3 5.1×group 1
2. F/T with other HH workers (377)			1.3×group 2*			9.0×group 2***
3. P/T with other HH workers (26)						
Household type						
1. 1 adult (141)				34% of group 2	15% of group 1	
2. 2+ adult (480)				1.4×group 1**	2.0×group 2***	

*Indicates a p-value ≤ 0.1.
**Indicates a p-value < 0.05.
***Indicates a p-value < 0.01.

between males and females within each subgroup. Table 6 summarizes the results for the adoption of a strategy. The table lists the main demographic factor, each subgroup within that factor, sample sizes for females and males respectively, and for each significant difference that occurred between male and female respondents, the percentage of females choosing a strategy within a tier and the probability ratio of females to males. For example, 57% of the 69 females within the 'single' category of the family status factor chose Tier 2. Females in this group were 2.3 times as likely as males within the same group to adopt a Tier 2 strategy, with a p-value less than 0.01.

Results

The results indicate that there are significant differences in adoption of coping strategies—primarily by gender, and secondarily by family status, income, employment status, and household type. The main results from Table 5, describing the differences between socio-economic subgroups for the adoption of strategies, are discussed below:

Gender. There were significant gender differences for four out of the six tiers, and in all four cases females were more likely than males to have adopted a strategy within the tier. In particular, they were 1.3–1.4 times as likely as males to change their work trip departure time or change their work schedule. They were also 1.5 and 1.9 times as likely as males to have adopted the costliest strategies of Tiers 5 and 6, respectively. There were no significant differences between males and females in the adoption of Tier 1 (auto improvement) or Tier 4 (remote work) strategies. (Females were, however, 1.2 times as likely as males to *consider* a remote work strategy of Tier 4.)

Family status. Respondents living in two-adult households without children were 1.1–1.3 times as likely as others (singles or households with children) to change their work trip departure time. This is not unexpected as households without children have fewer constraints than households with children. However, it is unclear why this tendency was not also exhibited by single-person households. It may be a reporting bias, as such a change would be less disruptive and hence less easily recalled for a single person.

Additionally, single-person households were less likely to adopt a remote work strategy, but they were 1.9–2.3 times as likely to relocate either their households

Table 6 Differences between females and males in the adoption of coping strategies

Demographic variables (No. Fs, No. Ms)	Tier 1 (a, b, c)	Tier 2 (e)	Tier 3 (j, k)	Tier 4 (m, n, o, p)	Tier 5 (q, s)	Tier 6 (t, v, w)
			Percent of females choosing Probability of base category to others			
Family status						
1. Single (69, 52)		57% 2.3***				
2. 2+ adults, no children (146, 129)			43% 1.4**			
3. 1+ adult(s), with children (113, 111)		58% 1.3**	50% 1.6***			23% 2.6***
Income						
1. $0–$34 999 (96, 20)						
2. $35 000–$54 999 (88, 105)		53% 1.4**	47% 1.4*			
3. $55 000–$74 999 (70, 70)			56% 1.6**			———
4. $75 000–$94 999 (36, 56)		58% 1.5*				59% 2.4***
5. $95 000 or more (30, 40)			57% 2.3***			———
Employment status						
1. Sole employed worker (118, 100)		59% 2.0***	39% 1.4*			
2. F/T with other HH workers (189, 187)			47% 1.3**		11% 1.8*	
3. P/T with other HH workers (21, 5)						
Household type						
1. 1 adult (87, 54)		59% 2.3***				
2. 2+ adult (241, 238)		58% 1.2**	47% 1.5***		10% 1.7*	18% 2.1***

*Indicates a p-value ≤ 0.1.
** Indicates a p-value < 0.05.
***Indicates a p-value < 0.01.

or their jobs. Both of these results are expected as single adults are likely to value the social interaction at the work place more highly (Pratt, 1984; Shamir and Salomon, 1985) and also have fewer constraints when moving or changing jobs.

Income. There were significant differences among income groups in the adoption of strategies in five out of the six tiers. Most interesting, the highest-income respondents were 1.2 and 1.7 times as likely as other income levels to adopt the lowest-cost strategies of Tier 1 and were 1.1 to 2.0 times as likely to adopt the remote work strategies of Tier 4, perhaps because they both involve higher out-of-pocket costs than, say, the time-changing strategies of Tiers 2 and 3. Conversely, the lowest-income respondents were 1.4 to 2.3 times as likely as other income levels to adopt the costlier strategies of Tier 6. The lowest two income levels were also more likely, at a 0.0006 level of significance, to adopt the relocation strategies of Tier 5. It seems that the higher-income respondents are more invested in specific locations, probably (in part) by having already internalized the effects of congestion in their location choice and other compensatory mechanisms (quality of car, residence, and so on).

Employment status. Part-time workers in multi-worker households were 1.3 and 1.6 times as likely as either sole employed workers or full-time workers in multi-worker households to adopt the flextime or compressed work week strategies of Tier 3. This result is interesting in that it suggests that part-time workers may have already explored other work schedule changes before going to part-time work. (It is intriguing that part-time workers were 1.3–1.5 times as likely as other workers to *consider* the remote work strategies of Tier 4, suggesting that they are still seeking a work style solution.) However, it may also represent a circularity, in that part-time workers may consider their part-time schedule itself to be a flextime or compressed work week situation, loosely defined. Such a circularity is clearly evident in the result that part-time workers were more likely to adopt Tier 6 strategies, one of which includes 'work part-time instead of full-time'. Aside from these two relatively spurious results, there were no significant differences in adoption across employment status categories.

Household type. Consistent with the earlier observation for the family status variable, one-adult households were less likely to adopt remote work strategies, and more (twice as) likely to adopt relocation strategies, than households with two or more adults.

The results in Table 6 describe the gender differences within each of the socio-economic subgroups. Again, in all cases exhibiting significant differences, females were more likely than males to adopt a strategy within a tier. Some of the relevant results from Table 6 are as follows:

Tiers 1 and 4. Table 5 showed that there were no overall gender differences in the adoption of Tiers 1 (auto improvement) and 4 (remote work). Table 6 shows quite clearly that this parity between gender for those two tiers holds at each level of each demographic variable examined.

Tier 2. For the Tier 2 strategy of changing work trip departure time, hypotheses in either direction are plausible. In traditional households we would expect men to leave for work earlier and women later in order for the latter to cater to household chores and get children ready for school. However, the strategy is to *change* departure time without specifying whether earlier or later. The results show that where there is a gender difference, women are more likely to be the ones making the change. Specifically, females of the following socio-economic groups were between 1.3 and 2.3 times as likely as males to change their work trip departure time: single-person and 1+ adult with children households, the second ($35 000–$54 999) and fourth ($75 000–$94 999) income categories, sole-employed household workers, and both one-adult and two-adult households (with or without children).

Tier 3. Tier 3 (flextime and compressed work week) had the most gender differences. Females in the following groups were 1.3 to 2.3 times as likely as males in the same groups to adopt: 2+ adults without children and 1+ adult with children households; income levels 2, 3, and 5; sole employed workers and full-time workers in multi-worker households; and two-adult households. This implies that females from a fairly broad spectrum are more likely to adopt work schedule changes in response to a congested commute and other lifestyle drives.

Tier 5. Tier 5, relocation, had only two gender differences: for full-time workers in multi-worker households and for two-adult households. Females were 1.8 and 1.7 times as likely as males in these same groups, respectively, to move either their homes or jobs. Analyzing this latter result clarifies the significant Tier 5 gender and household type results from Table 5, with the following story emerging: from Table 5, one-adult households were overall twice as likely to relocate as two-adult households, which is reasonable (as mentioned) since it is easier for them. Importantly, within one-adult households, no gender differences appear. Within two-adult households, however, women were 1.7 times as likely to report a relocation. It seems that this could be either because women in two-adult households are genuinely more likely to be the ones making the adjustment (a true distributional effect) or because women are more likely than men to identify

with and hence to report a partner's or a household move (a survey response bias)—or both. However, this result is partially at variance with the lack of gender differences within the family status variable in Table 6. Our confidence in the present finding would be higher if we had seen gender differences in the two-adult households without children and the 1+ adult households with children (91% of which had two or more adults) family status categories. As it is, since the gender difference for the two-adult household type is only significant at $p=0.09$ and is not corroborated by the family status results, we must view this outcome with some caution.

Tier 6. For Tier 6, containing the work part-time instead of full-time, start/expand a home-based business, and retire or stop working strategies, females in 1+ adult households with children, those in two-adult households with or without children, and those in the highest three income levels were quite significantly more likely (between 2.1 and 2.6 times) than males in the same groups to adopt. Women in 1+ adult households with children were also 1.4 times as likely as males in the same group to *consider* these costly strategies.

Discussion and conclusions

Transportation policies geared to reducing congestion are often based on simple behavioral assumptions and consequently fail to attain their objectives.

The analysis of the data in this paper supports the hypothesis that individuals perceive the set of alternative coping strategies as consisting of strategies ordered on the basis of costs. Thus, individuals are likely to adopt low-cost strategies before they adopt higher-cost strategies. Second, the wide range of coping strategies can be bundled into a number of tiers, again reflecting an increasing cost, but also offering different types of solutions to the problem of growing congestion. Some strategies cluster together as those which allow maintaining a given level of travel, while still reducing congestion costs, others reduce congestion costs by reducing travel and the third bundle involves a reduction of congestion costs by adopting location or lifestyle changes. One implication of these findings is that policy measures designed to reduce travel may have a smaller impact than expected, as individuals try first to maintain current levels of travel while reducing the personal impacts of congestion.

We further find support for the hypothesis that individuals who face increasing congestion view the choice of alternative coping strategies in a manner which is, among other things, dependent upon their socio-economic and demographic characteristics. The implications of this hypothesis are twofold. First, for purposes of policy analysis, it is necessary to forecast the impacts of policy measures. If different segments of the population exhibit differential responses to policy measures, it is useful to identify such variations so as to properly assess the potential effectiveness of planned policies. Second, if in fact there are such variations, it implies that equity issues should be explored so that policy measures do not adversely affect groups which may already be at some disadvantage.

The detailed analysis demonstrates that gender, family status, income, and household type are all related to the response pattern. However, most striking is the fact that women are remarkably more likely than men to adopt (or consider) behavioral adjustments to congestion. The available data can suggest but not definitively confirm some reasons behind this fact. It may be indicative of a real difference in coping mechanisms in which women are more willingly open to changes than men. However, an alternative explanation to this openness may depend on the perception of roles. It is plausible that in the case under study, gender differences reflect a difference in the perception of gender roles. If men perceive their work, and consequently their work trip, as being of greater importance or centrality in the household, they may see it as a pivot around which the household members and their activities should revolve. This argument implies that women are either overtly obliged to change their behavior more often than men, or have internalized this obligation in a way that manifests itself as being more open to changes. The strongest support for this explanation lies in the relatively large number of gender differences in Table 6 for households containing two adults compared to single-adult households.

Of course, the observed differences can also be a reflection of differences in reporting patterns. It is possible that women are in general more open to reporting their own adoption or consideration of behavioral changes, but it may also be the case that women in multi-adult households are more inclined to report a change in the household as if they have personally adopted it.

The data upon which the current study is based were collected for a study of telecommuting behavior and the items analyzed here were not the main focus of that study. At present, it is clear that given the distributional effects of response strategies and the complex dynamics of the process, a survey instrument which is designed specifically for this purpose is likely to reveal even more significant insights into the behavioral response patterns.

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