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Publication Date

1997-02-01

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Reprint
UCTC No. 360

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**Coping with Congestion: Understanding the Gap
Between Policy Assumptions and Behavior**

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Reprinted from
Transportation Research-D
vol. 2, no. 2, pp. 107-123 (1997)

UCTC No. 360

The University of California Transportation Center
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COPING WITH CONGESTION: UNDERSTANDING THE GAP BETWEEN POLICY ASSUMPTIONS AND BEHAVIOR

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(Received 22 August 1996; accepted 3 February 1997)

Abstract—With congestion being a major social and environmental cost of urban and metropolitan transportation, it has become a major target for policy-makers and planners. However, policies to curb congestion have had little effect. It is suggested that there is a wide gap between the assumptions which underlie policy measures and the manner in which individual users perceive and, consequently, respond to policy measures. This gap can partially be explained by the fact that the set of alternative responses to growing congestion is wider and somewhat different from that assumed by policy-makers. Moreover, the distributional impacts of various responses are such that their benefits and costs, as perceived by the user, create barriers to adoption. The dynamics of the behavioral response are also often overlooked by policy-makers, resulting in the promulgation of measures which have little or no effect on users' behavior. This paper reviews 16 possible behavioral responses from a coping strategy perspective, and emphasizes their distributional impacts. Finally, the paper analyzes some of the implications of the gap between policy-making and user response. © 1997 Elsevier Science Ltd

1. INTRODUCTION

Congestion is a major issue on the public and political agenda. It is often cited as the 'Number One' concern of urban dwellers or, more precisely, suburbanites and the newly growing group of exurbanites of large metropolitan areas (Cervero, 1991).

Congestion involves personal costs and major social costs. Consequently, it is a target of a wide range of policy responses, including large capital-intensive projects. The value of time lost annually due to congestion in the U.S. is estimated at \$48 billion (Arnott and Small, 1994). With a growing concern for environmental costs, the focus on congestion mitigation is also growing as congested traffic produces more air pollutants than smooth traffic flow, involves more noise production and consumes more energy. Thus, both the individual and society coincide in their perception of the presence of a problem but not so, however, in assessing the means for solution. Trends over the last two decades have demonstrated that little is accomplished by the variety of measures devised to reduce congestion.

A large body of literature has addressed the question of 'coping with congestion' (e.g. Giuliano and Small, 1994). Such studies often assume a certain set of behavioral responses to policy measures, which are largely based on the direct response to individual measures such as the effect of changes in the level of service or pricing on mode choice. Few studies have focused on the range of possible adaptation strategies (Goodwin *et al.*, 1992; Stern *et al.*, 1995; Koslowsky *et al.*, 1995).

This paper takes a critical view of some typical behavioral assumptions in the literature. It suggests that the view from the individual's situation is much different from that of planners and policy-makers. Hence, public policy efforts geared to reduce congestion may often be rendered quite irrelevant in achieving their objectives. Policy-making may benefit from an understanding of the manner in which the consumers of the transportation system view the scene.

Individuals pay for congestion in terms of out-of-pocket costs, loss of time and some additional maintenance costs resulting from slow 'stop and go' traffic conditions. Among the non-monetary costs are stress, a need to coordinate activities and possibly some health effects (Novaco *et al.*, 1990). Given that congestion increases the emission of air pollutants, there is also an additional indirect health effect (*The Economist*, 1994).

The social costs of congestion are the sum of the individual costs and the costs of the externalities imposed by individuals on others, including users and non-users of the transportation system. Congestion is commonly seen as a result of the gap between the two. As individual costs do not account for the social costs, drivers are inclined to behave in a manner which is socially undesired.

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. Very often, such policies assume that an individual will respond to a policy in a manner congruent with the social objective. Assuming that people will change their commuting patterns so as to improve the environment, however, may prove to be too optimistic. Very likely, individuals will respond in a manner which best suits them. As Arnott and Small (1994) have stated:

"It is also clear that some of the common-sense solutions do not solve the problem. Only by understanding the full nature of people's travel decisions and how they interact can sensible policies be formulated" (p. 455).

As congestion is a cost to the individual, coping strategies, in fact, offer two main alternatives: an internalization of the added costs or a transfer of these costs to other domains of life or other individuals. The main argument made in this paper is that issues emanating from the gap between policy and the individual perspective on the possible responses, including the transfer of costs, are important determinants of the individual's preference or ability to adopt particular strategies. We first present a conceptual framework for the analysis of behavioral adjustments to the situation of growing congestion which should have some implications for policy-making.

2. THE MISMATCH BETWEEN POLICY AND BEHAVIOR

The antecedents of congestion have been widely studied (Cervero, 1991; Downs, 1992; Giuliano and Small, 1994). Congestion is a result of the growing dependence of urban residents on the private automobile and the spatial and temporal distribution of their activities. This in itself may be viewed as an 'historical error', in which automobile use was underpriced from its very early appearance. Never did the automobile user account for the externalities involved in its use. One can only speculate at how urban areas would have evolved if that error had been avoided.

To a great extent, the co-location in time and space of work activities is the single most important determinant of congestion. However, as urban areas spread and the automobile-dependent suburban development covered large areas, congestion has evolved in the suburbs too (Cervero, 1986; Deakin, 1991). Moreover, the reliance on the automobile for non-work activities has also grown and most out-of-home activities of car-owning households now rely on the use of the car. Thus, congestion is increasingly also associated with afternoon and evening travel (Pisarski, 1992). The emerging phenomenon of exurbanization, namely a relocation into more distant areas, while still trying (and succeeding) to maintain urban jobs and amenities (Davis *et al.*, 1994) exacerbates the congestion problem (Giuliano, 1995). The current paper focuses primarily on congestion associated with the journey-to-work, as it is assumed that the behavioral responses to other congested situations (e.g. seasonal shopping or vacation travel) vary sufficiently to call for a separate analysis.

Historically, it is possible to identify at least three periods in which policy measures to curb congestion have emerged from very different assumptions about the nature of the problem. Initially, and through the mid-1960s, the principal tool was expansion of infrastructure: more roads were built to accommodate demand. Later, there was a shift toward improved management of the available infrastructure. This was the Transportation Systems Management (TSM) period which prevailed during the 1970s, and TSM is still a relevant tool. However, TSM is also limited in its potential contribution, and in the early 1980s there was an increasing realization that altering human behavior is the next necessary step. This led to the development and implementation of

Transportation Demand Management (TDM) strategies, involving a wide range of policies to reduce dependence on the drive-alone automobile.

While the first two periods can be characterized as emphasizing supply-side measures, the third is by definition designed to affect demand. Supply-side measures which cater to accommodating demand are likely to be positively received by users (albeit not necessarily by non-users, who may be the very same individuals when they are not behind the steering wheel). Politically, measures which infringe on constituents' personal behavior (and freedom) are considered undesirable and, therefore, according to Altshuler (1979), policy-makers refrain from implementing policies which have direct negative impacts on users, such as those directed at modifying demand. Rather, where possible, policy-makers will prefer a policy that 'looks good' even if its effectiveness may be limited.

The case of road pricing, widely advocated by transportation professionals as one promising congestion management policy, but so rarely applied, is a clear example of a policy that directly affects constituents' pockets (Emmerink *et al.*, 1994; Jones, 1991; Grieco and Jones, 1994; Wachs, 1994).

Supply-side and demand-side interventions differ in another aspect which is important in the current context. Generally, the direction of behavioral response to supply-side measures can be expected to conform to that anticipated by the policy-makers, and the question is whether levels of adoption will be lower than forecast (as is often the case for ridership on a new transit service) or higher (as when the release of latent demand triggers nearly immediate congestion on a new facility). However, in the case of demand-side measures, the individual is confronted with a situation which imposes a constraint. In this case, new 'outlets' are likely to be sought, and innovation may generate new, possibly unexpected responses, as described below.

Policy measures designed to alleviate congestion must be evaluated by a number of criteria such as technological and economic feasibility, time frame for implementation and political acceptance. A necessary criterion, which is often overlooked, is the behavioral test, namely an analysis of the response by the target population as to whether or not the measure will act in the desired direction. There are many examples where this criterion was not fulfilled and the measures consequently failed to attain their stated objective. During the 1980s, Athens, Greece, for example, introduced a curb on auto use to reduce automotive emissions. A given vehicle was allowed to enter the central business district area only on odd or even days based on the last digit of the license plate. The outcome was an increase in car ownership, where the second car was commonly older, polluting more than the new cars (Giaoutzi and Damianides, 1990). Such a response was not anticipated and rendered the policy not only useless but also counter-productive.

The assumptions that are (often implicitly) incorporated into congestion-mitigating policies seem to be part of the reasons for the relative lack of success in reducing congestion. The following assumptions seem to be particularly incongruent with current understanding of travel behavior:

1. Assuming fixed travel demand and ignoring the possible materialization of latent demand,
2. Assuming that travelers are cost minimizers rather than utility maximizers,
3. Assuming that only a limited choice set is available to the individual, and consequently that the addition of an option is likely to have a significant effect, and
4. Assuming that responses to demand-management techniques are similar to those for supply-side measures.

The aim of this paper is precisely the evaluation of commuters' responses to policies designed to reduce peak period vehicular travel, focusing on the implications of assumptions 2, 3, and 4.

3. BEHAVIORAL RESPONSES TO CONGESTION

Congestion is a state of the environment. People are exposed to this situation and may react to it in many different ways. The lack of success of many policies designed to curb congestion indicates that the range of responses as viewed by users may be different from those identified by policy-makers. This section focuses on identifying and classifying user responses, limiting the discussion to the responses relating to congestion in the journey to work.

The 'universal set' includes a wide range of reasonable responses. Each individual may not face this full set, but a subset of these. The individual choice set is determined by constraints as not all responses will be available to a particular individual. A basic list of likely responses includes 16 strategies which can be classified in various meaningful ways. Each of the strategies listed below is articulated in Section 5.

1. Accommodate congestion costs
2. Reduce congestion costs
3. Change departure time
4. Change route
5. Buy time
6. Invest in productivity-enhancing technology at home
7. Adopt flextime
8. Adopt compressed work week
9. Change mode of travel
10. Telecommute from home
11. Telecommute from a telecenter
12. Change workplace
13. Relocate home
14. Change from full-time to part-time work
15. Start a home-based business
16. Quit work

As can be seen, the list includes a variety of possible responses to increased congestion but many are not exclusively responses to congestion and may in fact be actions taken in response to other stimuli. While transportation policies usually aim to change travel attributes, the above list shows that some responses are very remote from travel attributes and affect other realms of life. Moreover, the responses, as will be emphasized below, have lateral impacts on other household members, not only the commuter.

The set of possible adjustments can be classified along several dimensions. Goodwin *et al.* (1992) have suggested a very useful classification of alternative adaptation options. They place coping strategies into a hierarchy, based primarily on the effort involved in the change, using this four-level classification:

1. Actions to increase the utility of existing behavior;
2. Actions that change travel behavior while maintaining the same activity set;
3. Actions that modify the basic activity pattern; and
4. Actions to modify the constraint and widen the choice of activities and travel opportunities.

Stern *et al.* (1995) have suggested a slightly different hierarchical classification, consisting of five tiers: lifestyle, location behavior, activity behavior, travel behavior and driving (passive vs active) behavior.

A complementary classification is based on time, permanence, cost, availability, degree of control and level of uncertainty. Each of these dimensions will be discussed below.

3.1. The temporal dimension

Time is a crucial element in the study of behavior, for at least two reasons: the *dynamic* aspects of decision-making, and the *time horizon* in which the individual considers her/his plans. The latter is a possible dimension for classification.

The time horizon to which individuals relate in the process of adjusting their behavior is important because, depending on how far away that horizon is, very different responses may be considered. Ben-Akiva and Lerman (1979) have suggested a hierarchy of decisions distinguishing between *mobility choices* (residential and work location, auto ownership and mode to work) and *travel choices* (mode for non-work trips, frequency, route, timing of trips, etc.). The latter group is focusing on the daily horizon whereas the former are decisions made with a time horizon of years. Thus, individuals probably consider some responses to be short-term strategies, which can be

adopted almost instantaneously, or on very short notice, while others are long-term and require long lead times to be employed. Some responses may even involve very long-term choices, such as changes in lifestyle. The distinction between short-term and long-term strategies may also imply that some responses may be viewed as temporary whereas others are permanent. The temporary ones are probably also more readily reversible.

3.2. The cost of adjustments

The cost of a response entails two elements: the direct expense and the transaction cost. The first refers to the actual cost of alternative coping strategies. 'Buying time' through hiring domestic help, for example, requires that the necessary costs can be borne. Similarly, relocating the home in order to reduce travel time may require an entry into more expensive housing. The costs may not necessarily be in monetary terms. A compressed work week may entail physical strain which is a cost too.

The second cost dimension refers to the transaction costs; that is, the (mostly non-monetary) costs of changing from an incumbent situation to a new one. While changing route of travel involves low transaction costs (costs of acquiring information, risk of being late due to losing the way), relocating a family involves very significant transaction costs. In some cases, the latter may be prohibitive due to the necessary adjustments required by all household members. The transaction costs also reflect the time necessary for deliberations about a behavioral change.

The 16 responses listed above differ in both actual costs and transaction costs. Travel responses tend to be less costly than mobility responses, but it should be noted that costs differ among individuals. For example, residential relocation is, by far, less costly for a single person than for a household with school-age children.

3.3. Availability of response strategies

Not all response strategies are equally ubiquitous. Some alternatives are simply not available to some individuals. For example, public transport may not be available. For others, the option of flextime may not be open, and so on. By adopting some changes, individuals may gain increased availability of responses. For example, by a change of employer to one who encourages telecommuting or allows flextime, an individual may alter his or her situation. It should also be borne in mind that individuals search for change, and engage in such changes, for a variety of reasons that may be very remote from their driving conditions. Yet, such changes may have an effect on their commuting.

3.4. Degree of control

The range of possible responses also varies in the degree of control the individual can exert. In some cases, the response is totally at the individual's discretion, whereas, in others, the response depends on other people, within or outside the household. Although changing route is clearly most often an independent decision, changing work schedules depends on the employer's agreement, and residential relocation is dependent on a household decision as opposed to a decision by the individual commuter. The degree of control also refers to taking the initiative to make a change. In most cases, we assume it lies within the individual but, in some cases, it may be the initiative of another household member or the employer.

3.5. Expectations and uncertainty

Response strategies also vary in terms of their expected alleviation of the congestion problem for the individual. Some may hold great promise (e.g. telecommuting from home), while others may be expected to carry only limited benefits. The magnitude of the expected contribution may affect the willingness to engage in deliberating about and adopting different strategies.

A related aspect is that of uncertainty about the magnitude of the expected contribution of each strategy. Each individual may be more or less knowledgeable about the nature of the responses in the choice set (and may also differ in attitude towards risk-taking). Thus, identification of the uncertainty involved in each of the response strategies is also necessary for understanding how individuals view the set of alternative strategies.

4. A MODEL OF COPING WITH CONGESTION

A commuter's coping with congestion can take very different forms, varying across individuals and situations. In this section, we first present the context of the behavior under study, followed by a description of the conceptual model of the decision-making process and its attributes.

4.1. Coping with congestion: the context

Increasing congestion is not the single worry individuals face in modern society. Individuals, in the course of their lives, encounter a variety of gratifications and difficulties in all three main domains of life: the household, work, and leisure. In each of these domains, an individual plays particular roles, which determine the amount and quality of gratifications and 'costs' one shares. There is some overlap among the various roles that a person plays (Hall, 1972). The overlap may be a source of conflict, or of satisfaction when the individual finds the various roles comfortably complementing each other.

Most likely, the individual is continuously in a need to cope with some conflicting demands. The demand to increase income may, for example, be conflicting with that of spending time with the family. The demand to spend more time on the highway due to congestion is very likely to be in conflict with other pressing demands for time, such as work or family commitments. In other words, we do not claim to innovate by suggesting that life is a complex phenomenon, in which changes are inter-related. They affect many facets of life. Efforts directed at resolving one problem are not divorced from other issues the individual faces. Our focus here is on how responses to congestion inter-relate with other aspects of the individual's life. More specifically, we suggest that in many cases, the adjustment an individual makes is likely to have an impact on others in the household or outside it or on other facets of life. It is these lateral impacts which we suggest are *cost transfers* of responses to congestion.

The implications of the argument raised above are that we cannot expect the individual to choose what seems to the observer/researcher to be the sensible or optimal solution. The individual's choice set is most likely constrained by various other demands not obvious to the observer, and not directly subject to manipulation by policy. Some other demands on the individual may be more unyielding than the 'demand' a congestion policy may make on behavior.

Consider, for example, the need to cope with the time loss due to traffic congestion. From a policy-maker's perspective, the solution to congested highways could be the introduction of rail service in a corridor so as to offer faster travel to the central city. However, from the commuter's perspective, such an investment may not offer any remedy. For a large number of drivers and car passengers, rail service is not at all competitive to the car (Bovy and van der Waard, 1991) in terms of travel time. For many more, it is not competitive because of its lack of temporal and spatial flexibility. So the mere fact that, on the trunk sections of a trip, rail may be faster than the car, does not contradict the fact that when tested for its overall level of service, it is in most cases inferior to the car. The advantage of rail in very high density areas is too often assumed by policy-makers to be generalizable to all urban situations, leading to many inefficient investments (e.g. Gomez-Ibanez, 1996; Pickrell, 1992).

4.2. The process

The process by which we suggest that individuals adjust to increasing congestion is described in Fig. 1. The basic cycle assumes that there is some level of dissatisfaction with travel conditions which triggers an individual to engage in a search for a solution. Given the experience gained, namely prior adjustments to congestion, the individual identifies the choice set and evaluates the alternatives, based on which a choice can be made.

Once a choice has been made, dissatisfaction may be reduced for a while but, in the context of increasing congestion, a threshold point of dissatisfaction may be reached again, triggering another search for solutions. This time, previously adopted solutions may not be feasible or desirable. However, it is also possible to choose an alternative repeatedly, such as adjusting work trip departure times, or changing routes. Consider the case in which some low-cost strategies were selected and, later on, a high-cost strategy such as a residential relocation was selected. Subsequently, the low-cost strategies may again be considered.

Fig. 1. A conceptual structure of the response to congestion.

This conceptual model may be implicit in many of the studies addressing mode, departure time or even location choice. In fact, it builds upon a model presented by Koppelman *et al.* (1993) which addressed the behavioral response to ride-sharing policies. Our model expands some particular elements and is more general in that it is not limited to one particular response (mode choice). The innovation of this model lies in three elements. First, it addresses the issue of search initiation, through an identification of the *dynamics* of the process. Second, also through the dynamic perspective, it focuses on the individual's limited *choice set* and, third, it articulates the implications of the *lateral impacts* as factors which affect the behavioral response. The last two items are included in what has been termed by others 'the situation' (Koppelman *et al.*, 1993; Brog and Erl, 1983). Each of these factors is described below.

4.2.1. The dynamics of the process. The dynamics of the process deserve significant attention to improve the likelihood of successful policy intervention. The timing of an adjustment decision, or deliberation about a decision, depends, among other things, on the history of such adjustments, as schematically described in Fig. 2.

With growing congestion there is a growth in dissatisfaction. At a certain level of dissatisfaction, a person is likely to consider a change in behavior. When a threshold level is reached, a process of searching for solutions to ameliorate the costs is initiated. The length of time to reach the threshold depends on the time elapsed since the previous behavioral change, the nature of that previous change, and the rate at which congestion increases.

Figure 2 illustrates a number of time-related factors that need to be considered in evaluating responses to congestion. First, the time necessary for deliberations following the initiation of the trigger is marked as A in Fig. 2. This depends on the type of responses considered at each iteration and the accumulated knowledge about potential alternatives that the individual holds. Second,

when a choice is made, some strategies require an implementation time (B in Fig. 2). Clearly, residential location cannot be implemented instantaneously, whereas leaving for work earlier can be done the next morning. The third temporal element relates to the timing of the expected benefit. In some cases (as shown in point C in Fig. 2), dissatisfaction is reduced instantaneously (shown by the vertical drop), as can be the case when departure time is significantly earlier than before. For other strategies, reduction in dissatisfaction over time may have different degrees of concavity or even convexity (e.g. slope D). For example, for a person opening a home-based business, which at least initially is likely to require much unanticipated travel, the delivery of the benefits will be accrued slowly, over time.

Another reason why the elapsed time is a relevant determinant of future responses is that there might be an inertia effect which may postpone an adjustment even if the benefits of a former one have expired (Goodwin *et al.*, 1992). Inertia (possibly showing as A + B in Fig. 2) may be a result of the expected transaction costs. If these are thought to be very high, the inclination for change is small. Second, inertia as observed by the researcher may be a result of lack of information by the commuter, or the time consumed in information acquisition or transaction.

A fourth factor is the 'maturity time' or lifetime of a change (the 'wave length', denoted as E in Fig. 2). If congestion continues to grow over time, the benefits of each behavioral change are likely to expire after some time. Departing from home early to avoid peak traffic levels is a clear example in which, after a while, the benefits of such a change dissipate. Given the situation of the individual, each response may be assumed by the individual to have a different expiration time. However, across individuals, it is likely that the ranking of responses in this respect are quite similar.

Understanding the issue of the time required for deliberation about change is important for policy-making considerations. This is likely to be a function of the transaction costs. Residential relocation is not a decision made on the spur of the moment, while route change may be. Thus, when a situation changes, or when a policy is introduced, there is a span of time in which each potential response may be employed. This is a very important point from a policy evaluation perspective. If a policy measure is evaluated before the range of likely responses has been adopted, premature decisions may result. The case of the Santa Monica (California) Diamond lane in 1976 may serve as an example (Billheimer, 1978). There, under political and media pressure, a High-Occupancy Vehicle lane was discarded soon after it was inaugurated, not allowing sufficient time for travellers to make the necessary adjustments (this does not mean that the project would have been a success if left intact, but the haste of its removal did not allow for sufficient adjustments to be made).

The threshold level of dissatisfaction which triggers a search need not be a single horizontal line as denoted in Fig. 2. In fact, it is likely that, over time, individuals change the level which triggers a deliberation for change. Note also that the expected benefits of a change (the amplitude, denoted as F in Fig. 2) differ among the phases. Some changes are expected to satisfy more than others, but it is plausible to assume that the actual outcome of a change is highly uncertain for the individual.

Yet another attribute of the dynamics of the process is the fact that while some responses are reversible (e.g. change in departure time) others are not perceived as such. This difference implies

Fig. 2. Adoption of strategies to reduce dissatisfaction over time. (Note: time frame refers to months or years).

that the amounts of information acquisition and deliberation are greater for non-reversible responses and consequently the response time is expected to be longer.

Also, some responses may be adopted on a continuous basis (e.g. altering departure time) while others are discrete in nature, namely they are characterized by an all or nothing outcome (e.g. residential relocation). This distinction adds to the complexity of identifying changes and evaluating potential changes in behavior.

Thus, the complexity of the dynamics of the response mechanism underscore the importance of identifying where the decision-maker is 'located' at a given time, so as to be able to assess his/her choice set and the attributes of those options, as perceived by the individual.

4.2.2. The choice set. The set of adjustment strategies listed in Section 3 is probably wider than that perceived by the individual. The individual is likely to exclude responses that have been exploited before, responses which are not perceived as promising (hence the importance of attitudes measurement) or responses which are unavailable due to some internal or external constraint. However, the choice set may include alternatives which are feasible but not desired, whereas the preference set may include alternatives which are desired but not feasible. Hence, it is important to study the *intersection* of the choice and preference sets.

4.2.3. Lateral impacts. The argument developed in the next section is that many of the responses to congestion entail lateral impacts. They affect other members of the household, positively or negatively, and/or they have ramifications on other facets of the individual's life. This is not a new idea, but we suggest that much more attention must be paid to these impacts if policy analysis is to be relevant. In some previous studies, these lateral impacts were termed 'situational factors' or, in other cases, some of them were considered implicitly. However, most reference to these factors is through conventional socio-demographic and economic indicators, such as the presence of children, age, income, auto availability, etc.

The claim here, following others, is that such 'objective' indicators are poor predictors of behavior (e.g. Koppelman *et al.*, 1993), as individuals in similar objective situations may have different subjective perceptions or attitudes towards these factors, and therefore different responses. This is clearly shown in Mokhtarian and Salomon's (1997) discussion of the role of constraints and drives in affecting telecommuting preference and choice. While telecommuting is now widely advocated as a sensible response to congestion, few people to date have adopted it. A drive supporting telecommuting can be the desire to spend more time with the family. However, for other individuals or even for the same individual, spending more time with the family may be viewed as a distraction from work, and thus a constraint on the ability to telecommute. This distinction cannot be identified by common socio-demographic indicators. The possible lateral impacts alongside the attitudes toward relevant aspects of family, household and work are more promising as explanatory factors.

We suggest that in evaluating the set of feasible alternatives, the individual is likely to consider the benefits and costs in the context of the lateral as well as direct impacts.

5. DIRECT AND LATERAL IMPACTS OF COPING BEHAVIOR

As suggested above, the distribution of direct and lateral impacts affects the individual's choice. He or she will evaluate various costs and benefits by the extent to which they are incurred by oneself or the household or, in contrast, by other members of society.

Table 1 presents the universal set of responses, emphasizing the perspective of which costs or benefits are incurred and by whom they are incurred: self, household, or others. For the household, the table indicates only those cases in which a transfer may occur; that is, cases in which a benefit to the individual results in a cost to the household or *vice versa*. Otherwise, a benefit or cost to the individual is assumed to accrue to some degree to the household as well, and is not shown separately. For the other members of society who are subject to the impacts of congestion, the cost or benefit is indicated to be primarily in terms of time, but may also include the previously mentioned elements of monetary costs, stress, health and so on. Some strategies further involve benefits, unrelated to congestion, accruing to certain segments of society. For example, the strategy of reducing the costs of commuting by means of purchasing better cars, gadgets and cellular telephones may have broad benefits in terms of stimulating the economy. Such second order externalities are mentioned only in passing here.

Table 1. Incidence of costs and benefits for various adjustment strategies

Responses	Nature of effect	Cost/Benefit accrues to:		
		Self	Household	Others
1 Accommodate travel costs	Time	C		C
	Stress	B		
2 Reduce travel costs	Monetary	C		
	Time	B	C	C
	Stress	B		
3 Change work-trip departure time (unofficially)	Time	C/B	C	B
	Inconvenience	C/B	C	
4 Change route	Monetary	C		
	Time	C		B
	Stress	B		
	Effort	C		
	Risk	C		
5 Buy time	Monetary	C		
	Time	B		C
	Effort	C		
	Risk	C		
6 Invest in productivity-enhancing technology at home	Monetary	C		
	Time	B		C/B
	Effort	C		
7 Adopt flextime	Time	B		B
	Inconvenience	C/B		
8 Adopt compressed work week	Time	C/B		B
	Inconvenience	C/B		
9a Change mode from auto to transit or ridesharing	Monetary	B		
	Time	B		B
	Stress	B		
	Inconvenience	C		
	Effort	C		
9b Change mode from transit or ridesharing to auto	Monetary	C		
	Time	B	C	C
	Stress	C		
	Inconvenience	B	C	
	Effort	C		
10 Telecommute from home (part- or full-time)	Monetary	C/B		
	Time	B		B
	Stress	C/B	C/B	
	Inconvenience	C/B	C/B	
	Risk	C		
11 Telecommute from a local work center (part- or full-time)	Monetary	B		
	Time	B		B
	Stress	C/B	—	
	Inconvenience	C/B	—	
	Risk	C	—	
12 Change to a new job in a new location	Monetary	C		
	Time	B		B
	Stress	C/B		
	Effort	C	—	
	Risk	C		
13 Relocate home	Monetary	C		
	Time	B	C	B?
	Stress		C	
	Effort		C	
	Risk	C		
14 Change from full-time to part-time work	Monetary	C		
	Time	B		B
	Stress	C/B		
	Effort	C		
15 Start a home-based business (or put more effort into an existing one)	Monetary	C/B?		
	Time	C/B		B
	Stress	C/B		
	Inconvenience	C/B	C/B	
	Effort	C		
	Risk	C		
16 Quit work	Monetary	C		
	Time	B		B
	Stress	C		

The elements of Table 1 naturally represent only general tendencies; there will be variations depending on particular situational contexts. Nevertheless, several important observations may be made from the table. First, some of the most feasible, lowest transaction-cost and, therefore, most popular adjustment strategies (namely strategies 1, 2, 5 and 6) leave society bearing the costs of congestion. These strategies alleviate some of the burden of congestion for the individual, but do not have a social benefit. The demand for road traffic is not reduced, and it may even be increased.

Second, by contrast, for society to obtain the benefits of congestion relief, major changes in lifestyle are often involved, as in strategies 10–16. Lifestyle decisions are the longest-term resolutions individuals make, much longer than their mobility and travel decisions (Salomon and Ben-Akiva, 1983). If lifestyle is seen as a set of preferences as to how one would like to allocate time among work, home and leisure, changes in lifestyle involve a reassessment of one's preferences. Such changes are very long term in nature and usually, for the individual, are a result of long deliberations. While it is reasonable to assume that individuals suit their travel decisions to their lifestyle preference, it is much less likely to assume the reverse, namely that individuals adjust their lifestyle due to congestion. This may explain the fact that many transportation improvement strategies, so anticipated by policy-makers, make only minor dents in the prevailing travel patterns. The case of the introduction of rail service may be a good example. Finally, every strategy involves lateral impacts of both types: costs (and benefits) to the household, and impacts on non-transportation aspects of the individual's life.

The impacts of each strategy are discussed in more detail below.

1. Accommodate travel costs: This 'do-nothing' situation, which obviously is a prevailing response, is an indication that despite the public and political grievance about congestion, it may not be as severe a problem as commonly believed. In economic terms, it implies that the costs of adopting any other response strategy are greater than the costs of congestion to the individual. This may be true, among other reasons, because the cost of change itself is perceived to be very high, independent of the actual costs of the contemplated strategy. In fact, as Gordon and Richardson (1991) and Levinson and Kumar (1994) have indicated, congestion may have become more prevalent on urban roads, both in temporal and spatial dimensions, but that does not necessarily imply that individuals spend more time in congestion. They may have already adopted other adjustments, so that the cumulative social costs of congestion-related time loss may not be incurred by the individuals involved.
2. Reduce travel costs: The automobile and car-gadget manufacturers seem to cater to the frustrated driver by offering an increasingly pleasant and functional 'commuting environment' (and, hence, this market represents an economic benefit to those particular segments of industry). Air-conditioning, a quality sound system, a cellular telephone, and other elements of comfort all make the time spent travelling by auto more acceptable. The cellular phone significantly reduces the costs of the lost time, as work or personal business can be pursued while travelling. This strategy implies that the individual is reducing the costs of congestion without reducing the amount of travel. Thus, the increase in congestion does not necessarily imply a proportional increase in the frustration level of the commuter. Frustration may be growing at a slower pace (although for some individuals it may be growing faster).

The psychology of commuting may be instrumental in explaining why these first two options are so widely accepted. As Richter (1990) pointed out, there seems to be a personal need for a transition between the various roles a person plays in life. Commuting time may serve as a buffer which facilitates the transition from home (family) roles to workplace roles, and *vice versa*. The length of such a transition probably varies widely among individuals. However, commuting in this context serves a positive function which will be eliminated by adjustments such as telecommuting.

It is impossible to observe, without further analysis, the difference between strategy 1 and strategy 2 adopters, and possibly the distinction is blurred for the commuters themselves. Gasparini's (1995) typology of waiting time is of relevance in the distinction between strategies 1 and 2. The former strategy is one in which waiting is an interstitial time, perceived largely as a cost, whereas the latter is a case in which waiting is still an interstitial time but it is filled with a substitutive meaning (e.g. listening to music, talking on the phone, etc.). The

latter is referred to by Gasparini as "equipped waiting". Strategies 1 and 2 seemingly involve a most important way of coping with commuting under congested conditions, namely a psychological adjustment or cognitive coping (Novaco *et al.*, 1990). It is suggested in the psychological literature addressing time perception (Brown, 1990; Zakay, 1991) that the assessment of time is very much a question of a state of mind. In the present context, this would mean that if individuals enter the car in the morning with the knowledge and acceptance that commute time will be 60 min, the anxiety and perceived time costs will be lower than if one expects a 45 min drive and is stuck in an unexpected jam for an additional 15 min.

One difference between the two strategies is that, for strategy 1, both commuters and their households pay the time cost of commuting whereas, for strategy 2, the commuter's time cost is mitigated while the household's is unaffected (that is, the household still loses time with the commuter due to congestion).

3. Change departure time: This strategy can reduce travel time if the peak period is relatively narrow. It will be less effective in those areas where congestion prevails for many hours continuously. Constraints such as rigid work schedules or the need to cater to the schedules of other household members, especially children (Moore *et al.*, 1984; Gordon *et al.*, 1990) entail higher costs for this strategy or preclude it for some commuters. When the strategy is adopted, it may or may not benefit the commuter, but it most likely costs the household regardless. For example, if a spouse decides to leave early, it implies that his or her counterpart must take responsibility for children's needs in the morning. This strategy exemplifies the point that, given multiple competing demands faced by an individual and the household, finding a solution to one problem may in turn exacerbate others.

Note that this strategy may not necessarily be adopted to save time or avoid congestion. As congestion increases, the reliability of travel time deteriorates. There is a growing probability that major delays will occur due to minor incidents on the road system. Thus, strictly to avoid tardiness, individuals may resort to allocating longer time spans for travel (Caplice and Mahmassani, 1992; Chang and Mahmassani, 1989; Stern *et al.*, 1995).

4. Change route: By changing to a route with less stop-and-go traffic, the traveler may reduce commuting stress even though the new route may be longer or slower. Increasing the visual or aesthetic appeal of the trip may also be a reason to change to a longer route, with a similar stress-reduction benefit. Although this appears to be a relatively simple strategy, it does involve a number of costs to the traveler, including monetary (assuming the new route is longer or if it involves a toll), a longer travel time, the effort to find and try the new route, and the uncertainty or risk associated with the change (including, perhaps, reliability of arrival time and safety considerations). This strategy may save time on a systemwide basis by reducing congestion on heavily traveled routes. But local traffic and environmental impacts may be negative in the surroundings of the chosen route if it is not equipped to carry through-traffic.
5. Buy time: This is another popular strategy which, although also involving some costs, has a clear benefit to the traveler and, in most cases, to the household as well. There is further a benefit to those segments of the economy which offer time-saving services (such as cooking, cleaning, etc.). Child care is one time-buying strategy that carries a risk, so much so that some parents will prefer other responses over that alternative. This strategy is an example of a 'spill-over' effect, whereby the behavioral response occurs in a domain which is remote and divorced from travel decisions, or from the policy arena of transportation professionals, but its motivation can be traced, at least in part, to the congestion levels experienced by the individual. In this respect, such changes should be viewed as externalities of travel, some of which may partially off-set other externalities.
6. Productivity-enhancing technology: Investing in technologies for the home that increase productivity is another way of buying time. In this case, economic benefits are obtained by industries related to such technologies. To the extent that the technology supports earning a living at home (e.g. using a computer to telecommute), others benefit from the reduced commuting (and the household also enjoys the additional educational and entertainment opportunities made possible by the computer). But in some cases (e.g. the microwave) the time saved by the technology supports the continuation of the commute. This too is a strategy that may generate some positive externalities.

7. **Flextime:** Flextime may afford a relatively easy way to avoid peak-period congestion. However, not all employers offer the option and, for some commuters and their households, it may be inconvenient to leave for work much earlier or later than the normal time. Numerous studies on the effect of flextime have reported that constraints (which in the current context can be interpreted to represent costs) limit the utilization of this option (Bac, 1993; Gordon *et al.*, 1990). However, the flexibility offered by this option is likely to reduce stress associated with travel, as there is no penalty for late arrival. Moreover, even if the option of flextime is not exploited by the individual on a regular daily basis, its availability is a comforting cushion for the household when irregular circumstances arise and result in a time shift.
8. **Compressed work week:** Working less than the conventional five-day work week allows an individual to spend less time during the week on driving to work. Moreover, as most compressed schedules imply longer work days (9–10 hours), there is an increased probability that travel to or from work will not be during the peak. This option is similar to flextime, except that the longer workdays may impose more of a cost on the traveler and the household by reducing the time available at home during the work week.
9. **Change mode:** Switching to other, more efficient, modes of travel is often the solution suggested by transportation professionals, environmentalists and politicians. However, based on experience, the success of that particular approach is limited to situations where congestion is very severe and shared-ride modes are competitive in time and cost to the automobile (e.g. in CBD-bound trips where parking is limited and costly). In those cases, switching affords a benefit to the traveler in terms of money, time, and stress. However, there is a cost in inconvenience and loss of scheduling control and in the effort of finding the necessary information and making the change. Further, the previously sunk cost invested in the automobile often presents a barrier to change.

When the transit or ride-sharing modes share the same congested roadway as the single-occupant automobile, some travelers will eventually be motivated to switch to driving alone so as to enjoy the increased flexibility offered by the car. This entails a monetary and stress cost in exchange for the benefit of convenience and, of course, imposes an additional time penalty on other travelers using the same road system.

10. **Telecommute from home:** Home-based telecommuting is a strategy requiring the employer's support, and whose pros and cons vary depending on the individual situation. Financially, it may be a benefit (since commuting and some other expenses are saved) or a cost (if equipment or services must be purchased by the telecommuter). Similarly, telecommuting may reduce stress and increase personal convenience or, if the worker feels pressure to produce extra work or fails to properly balance home and work demands, may have the opposite effect. The impact on the household may be congruent with or contrary to that for the individual. For example, if space is constrained, telecommuting may increase convenience for the individual at the expense of decreasing it for the family (Gurstein, 1991; Shamir and Salomon, 1985).
11. **Telecommute from a local work center:** Working from a telecenter (Bagley *et al.*, 1994) eliminates the congested part of the commute. Telecenters may also encourage the use of non-motorized modes such as bicycling and walking. Telecommuting from a center differs from the home-based form in that the employer is more likely to bear the costs, and the costs to the household become insignificant (while the benefits enjoyed by the telecommuter are probably still shared by the household). Both forms of telecommuting may also offer other benefits to society as a whole and particularly to certain segments such as the mobility-limited (Mokhtarian, 1991; Hesse, 1995).
12. **Change workplace:** Relocating the work place closer to home or to a less congested area is one of the longer-term adjustments. In most cases it involves leaving the employer for another one, although in some cases (e.g. multi-branch operations, like banks) it may allow a movement between facilities, decreasing the costs associated with such a change. Changing employers is a major response, certainly involving a great deal of effort (on the part of the individual) and risk (to the individual and the household). There may be a monetary cost, as some people appear willing to trade off a lower salary for a less strenuous commuting journey. Stress is probably increased in the short term, but may decrease in the long term.

13. Relocate home: Changing residential location is another response with major costs to the household, which often bears the greater part of the stress and effort of moving. Both the individual and the household bear the monetary costs and the risk of uncertain satisfaction with the new location. If the move is made to save commuting time for one spouse, it often increases the time for the other, although the net effect on the system is presumably still a benefit.
14. Change from full-time to part-time: Changing from full-time to part-time work can be effected either by working on a shorter daily schedule, thus avoiding peak-period traffic conditions, or by reducing the number of work days. Such changes obviously have important monetary implications for the individual and the household, which may induce some stress (on the other hand, there is also relief from the stress of commuting as at least a partial compensation). There may well be some effort involved in finding suitable part-time work, which may mean changing jobs and/or employers altogether. Changing the amount of involvement in work is clearly a lifestyle choice, with wide ramifications beyond commuting.
15. Start a home-based business: This strategy entails costs for the individual along with potential benefits like monetary gain, time, lower stress (greater control of one's work), and convenience (schedule flexibility). Space constraints and other considerations may lead to inconvenience for the household independently of the impact on the individual. Again, it is not very likely that an individual will adopt this strategy as a direct outcome of growing congestion. There are probably other antecedents to such a decision. Growing congestion may certainly contribute, however, or serve as a trigger to engage in the change. Such a change may involve much irregular travel for business purposes, but the travel can often be at off-peak periods and to less congested locations.
16. Quit work: This response carries a monetary cost even greater than that of strategy 14. If the motivation to quit work is predominantly the stress of congestion, the result is likely to be deep frustration. Quitting work, which was mentioned earlier as a radical act, may in fact be quite common. We suggest that many people who do not work are those for whom the given (mostly time) costs of congestion have exceeded the costs of other responses and the benefits of work. This may be more common among women compared to men.

6. POLICY AND RESEARCH IMPLICATIONS

The main argument brought forward in this paper is that growing transportation costs, in the form of congestion, elicit a variety of possible responses by the users of the transportation system, and that understanding the response mechanism is necessary for formulating effective policies. The relationship between environmental policy and behavioral response is complex, and simple assumptions about the expected results may lead to futile and often expensive policy experiments. The conceptual model of the response behavior suggests that two aspects warrant more attention than past analyses have given; the implications of the dynamics of the decision process, and the incidence of costs and benefits of behavioral adjustments.

Understanding the response process requires an analysis of its inherent dynamics. Previous experience and the length of time since the last behavioral adjustment are among the temporal aspects that require attention. Behavioral adjustments, it is suggested, bring about a redistribution of the costs of congestion among the user, his or her household members and society. The incidence of such costs and benefits affects the preference and, in turn, the choice of adjustment strategy. Both these aspects, the dynamics and the cost redistribution, have profound effects on a number of issues. Some of these issues are discussed below.

6.1. Distributional effects

The individual's choice set is determined not only by past experience but also by the constraints which act either on the costs of response strategies or on their availability. The fact that coping strategies vary in cost and availability implies that there is a potential distributional effect in the sense that different individuals or households can only respond by adopting certain measures which they can afford, and by not adopting others.

Low-income people are barred from some alternative responses if their available resources are insufficient. There is a distributional effect on the basis of occupational group. Some occupations do not facilitate some of the responses, e.g. telecommuting (Mokhtarian *et al.*, 1997). Gender differences are of particular concern in this respect. As more women enter the paid labor market, while still catering for the larger share of household chores, greater time-space constraints act upon women. This implies that the range of possible responses is usually smaller for women than men. The difference may, in fact, be between married women with young children and other working adults, male or female (Pazy *et al.*, 1996).

Some congestion patterns and strategies for coping with them have distinct spatial patterns. Congestion seems to be growing at a fast rate in suburban settings, where automobile dependence is much higher than in urban areas. Also, the strategies considered may have differential spatial implications, both from an environmental policy-making perspective as well as from the individual's perspective. For example, public investment in transit services in the suburbs, in an attempt to reduce automobile use, is sometimes achieved at the expense of such services within cities. On the other hand, some of the more successful measures to reduce congestion and improve air quality may reduce the travel costs for the individual and result in relocation to more distant suburbs to entertain other amenities.

Distributional effects not only constrain the choice set but may also change the relative positioning of particular options. The relative costs of each possible response may be viewed differently and thus its inclusion or position within the choice set may differ.

The existence of distributional effects should be of concern to policy-makers as such effects may be in conflict with other societal objectives, such as equity. It implies that, in the process of policy formulation and policy analysis, the distributional effect should be considered together with remedies so as to avoid the generation of new problems by solving old ones.

One of the important implications of the existence of distributional impacts and the fact that the situation of the decision-maker is of vital importance for the understanding of his/her possible responses, is the need for market segmentation in policy-making. However, market segmentation is only relevant if the factors which explain responses to environmental stimuli (policy measures) are distributed in identifiable groups. While some of the factors are easily identified (e.g. the presence of young children), others are more covert. Moreover, simple socio-demographic characteristics, as noted above, are poor predictors of response behavior, as even the presence of young children is a very coarse indicator of a constraint on mothers' behavior. Mothers may share responsibilities with their spouses or may hire help to relax the constraint on their commuting behavior. Income is another straightforward segmentation variable, but is again potentially quite inexact.

At this point, relevant bases for segmentation have not been definitively identified. We hypothesize that there are a number of potentially fruitful dimensions, including recent adopted adjustments, attitudes and lifestyles.

6.2. Implications for data collection and research

The model presented above provides a step toward a broader and deeper understanding of the relationship between transportation/environmental policy and behavioral adjustments by those upon whom the policies are enacted. The model should be tested in an empirical setting. However, it is already possible to point to some implications for further research, as well as data collection.

Given the widely accepted notion that simple socio-demographic variables are poor predictors of behavior, we suggest that the following type of information would lead us to improve the predictive quality of models. First, we believe that, given the dynamics of the choice process, it is necessary to collect data either on a longitudinal basis, or on the past experience of the commuters. Much of their future behavior, it is suggested, can be explained by the responses they have already exploited. Thus, direct questions about past adjustments and their timing seem to offer the necessary information.

It is also important to obtain information on the extent to which an adjustment is considered or adopted specifically in response to congestion, rather than as a response to another drive. As stated earlier, a response for other reasons can still have travel impacts but, to assess response to transportation policies, it is important to know the reasons for adoption.

Attitudes are crucial explanatory variables, in particular when the possible alternatives range

from simple travel changes to major lifestyle decisions. The tools for attitudinal measurement are readily available, but are not commonly used in travel behavior surveys. The main problem with attitudinal data is its limited utility for forecasting purposes. Nevertheless, we do suggest that collection of such data should be undertaken more often to strengthen the understanding of behavior.

As noted above, an understanding of the potential lateral impacts of the choices faced by individuals is also important for explaining responses to congestion. Some of this data is often collected (e.g. attitudes and situational indicators), but it should be emphasized so as to allow the proper analysis. Again, the problem arises in utilizing this type of information for forecasting purposes. Despite this, there is still significant value in the inclusion of attitudinal and situational data to gain more insight into the impacts of suggested transportation/environmental policy measures, even if that insight is not directly translated into quantitative forecasts.

Acknowledgements—The authors would like to thank Tammy Sofer for the graphic work. Partial funding for this research was granted by the Hebrew University Fund for Environmental Studies (study of evaluating policy interventions to reduce environmental costs of transport), and by the University of California Transportation Center.

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