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Elasticity-Based Method for Forecasting Travel on Current Urban Transportation Alternatives

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This paper presents a quick-response incremental travel demand forecasting method that uses travel demand elasticities and readily available ground count travel and land use data. Elasticities are defined and criteria for selecting elasticities are identified. The steps for calculating each component of travel affected by a transportation improvement are described. Personnel and computational requirements for this method are greatly reduced relative to those necessary for forecasting with the conventional four-step sequential process (trip generation, distribution, modal split, and trip assignment). The basic travel behavior assumptions of the method are similar to those inherent in conventional models although, in contrast to sequential derivation and application of these models, internally consistent causal relations are maintained. A range of outputs of interest to policymakers is generated, including changes in total travel, changes in mode-specific travel, and changes in travel on a given route or link. The elasticity-based method has recently been used to forecast patronage on the four major transit alternatives included in the Baltimore North Corridor alternatives analysis. This application is described in the paper and compared with forecasts made in a particular application of the conventional four-step sequential travel demand forecasting system for the same alternatives under the same conditions. This direct comparison of the two forecasting methods provides a unique opportunity to assess the effects on forecast patronage of many assumptions inherent in typical applications of each method.

Much of the concern over urban travel demand forecasting involves the turnaround time and expense of applying existing conventional sequential travel demand models. Also, application of these conventional models often involves a series of restrictive assumptions that can reduce severely their ability to distinguish travel impacts between alternatives (1). These models synthesize travel patterns from scratch based on a long list of land use, socioeconomic, and level-of-service variables, which themselves must be forecast (thus propagating errors) (2). One way to cut significantly the large costs currently associated with urban travel forecasting is to use elasticities with respect to those limited numbers of variables related to the policy option of interest. Also, since elasticities can be behavioral, the spatial extent of the forecasts can be limited to those areas of the region affected by the system change being tested. The most easily available travel data, namely ground count data, can be factored incrementally at some useful and informative level of aggregation. Such an approach saves the time, expense, and uncertainty involved in forecasting and calculating entire sets of independent variables.

The elasticity-based approach described here has recently been used to forecast patronage on four major transit alternatives considered in the Baltimore North Corridor alternatives analysis. In addition to the elasticity-based forecasts, patronage estimates were developed by the Baltimore Regional Planning Council by using the existing four-step, sequential forecasting system estimated with urban transportation planning system (UTPS) software. Hence, the opportunity to compare and evaluate the two methods was provided.

ELASTICITIES

A travel demand elasticity is defined as the percentage change in ridership or traffic volume (depending on what is measured) that results from a 1 percent change in a given independent variable (e.g., travel time or cost) (3). Elasticities are measures of the partial effect on travel of changes, taken singly, in the travel environment that confront travelers. They allow shifts in travel patterns to be estimated at the margin in response to changes in the travel environment and, therefore, existing observed travel unaffected by changes is preserved. Existing synthetic (UTPS) procedures can only duplicate existing travel with some difficulty.

Elasticity-Based Forecasting Method

The elasticity-based forecasting procedure is based on the concept that travel on a new or improved transit facility is composed of four components, each of which results from one mutually exclusive cause or behavior and each of which can be calculated separately and sequentially to include the results of the previous change. The four components are as follows:

1. Transit travel that does not exist today due to growth in numbers of people and jobs; these are changes in travel due to so-called long-run demand, or land use changes;
2. Transit travel that is diverted from (or to) the automobile mode due to changes in automobile-operating costs (e.g., increases in gasoline price) and other automobile level-of-service changes (e.g., reductions in travel time due to highway construction);
3. Transit travel diverted to the improved transit facility from transit facilities for which the new or improved transit facility is a superior substitute; this is diverted travel from facilities of the same mode; and
4. Induced transit travel, or travel that is induced in the corridor and specifically on the transit alternative being evaluated as a result of the new or improved transit facility; induced transit travel includes travel that results from increased rates of choice of destinations served by the improved facility and increased transit trip

frequency (including automobile trips diverted to the transit improvement).

To calculate the first travel component due to land use changes, the origin-destination (O-D) superzone transit trip table is factored to account for growths (or declines) in population and employment. Simple proportional factors on numbers of households and jobs are used to account for growths and declines in transit travel. This assumes a long-run equilibrium between the preferred residence and employment and other activity locations of people, and the travel choices available to them. To account for the fact that the population mix, for example, in a residential neighborhood will change to reflect the (long-run) behavior of people to locate in accordance with their transportation preferences, long-run elasticities must, for the sake of consistency, be used to calculate the second and fourth components of travel.

Because transit demand is a function of both automobile and transit level of service, the second component of travel includes only the change in transit use that results from changes in automobile level of service. Transit trips are factored by using cross-elasticities of transit demand with respect to automobile level-of-service characteristics. No assumptions need to be made that transit is directly substituted for all automobile trips foregone as a result of gasoline price increases, for example, even for work trips. The transit demand cross-elasticities, empirically derived, provide the proportion of automobile trips foregone that use transit in the given situation. In particular, the cross-elasticities provide the percentage of change in transit use that results from each 1-percent change in each automobile level-of-service characteristic.

To calculate the third travel component, diverted transit travel, the amount of transit travel between each superzonal pair on each affected transit route that is diverted to the transit improvement or alternative is calculated. This calculation is based on level-of-service differences between the existing routes that serve the O-D pair and the alternative being tested. The resulting diverted transit trip table will already have been factored appropriately to account for growth in transit travel due to land-use changes and travel from automobile due to changes in the automobile system (travel components 1 and 2).

The alternative-specific superzonal transit trip table (from component 3) is factored by using direct transit elasticities applied to the transit level-of-service differences between the new alternative and the existing bus routes from which travel is diverted to calculate induced travel from the transit improvement.

Calculation of the first two components of travel results in the forecast year transit trip table that reflects the future year population and highway level of service on the base year transit network. Hence, the stage is set for introducing the transit alternatives. With the introduction of new or improved transit lines, existing transit trips will be diverted to the new routes (component 3). This diverted travel represents the base transit ridership on the new routes, which is then factored to reflect the increase in travel (component 4) induced as a result of the improvement in level of service.

Assumptions

The approach outlined above is based on certain behavioral assumptions that should be made explicit. Certain basic assumptions are no different from the assumptions inherent in the conventional sequential series of steps in urban travel forecasting. However, calculation of the four components of travel uses internally consistent relations that account explicitly and appropriately in each step for changes in trip frequency (trip generation), destination choice (trip distribution), modal choice (modal split), and trip diversion (assignment). Changes are calculated in all of these travel choices for every change in the transit and highway system. The lack of feedback to these choices in the usual UTPS process is avoided. Double counting of changes in travel choices is also avoided. That is, in the traditional sequential four-step modeling process, changes in travel behavior in more than one travel choice are contained in the data used to model or explain a single travel choice. When single travel choices are forecast sequentially by using models derived in this manner, the effect is to count changes in these choices several times and thereby inflate the impact of these changes on travel behavior.

The following mapping of the conventional sequence of travel choices on the explicitly and uniquely calculated travel components is helpful.

Long- or Short-Run Travel Choice	Travel Component
Population and employment growth, decline, or redistribution	1
Transit trip frequency, destination choice, and modal choice due to changes in automobile level of service	2
Transit trip frequency, destination choice, and modal choice due to change in transit level of service	4
Transit path choice	3

The time of day travel choice is omitted here for ease of presentation. It is addressed in the Baltimore study through the development of alternative-specific peaking factors that reflect how this travel choice varies with the transportation improvement. Because it goes back to land use changes (component 1), the method assumes a long-run equilibrium between the preferred residence and employment (and other) locations of people and the travel choices available to them. This generally requires that elasticities should be used that have been derived from models estimated by using only a certain kind of data, namely cross-sectional origin-destination data (1). This is not a constraint because most models are estimated by using such data collected at one point in time. The distinction between short- and long-run elasticities is important because it has been found that elasticity estimates based on models calibrated with cross-sectional data are consistently larger than short-run elasticities based on before and after studies (4).

Criteria for Selecting Elasticities

Although the application of elasticities is a relatively simple procedure, the elasticities selected for use in the forecasting approach described above must be consistent with the travel demand changes being measured. For example, models based on cross-section data are often estimated for a given trip purpose and involve a single travel decision such as modal choice. Other models, known as direct-demand or simultaneous-choice models, include a range of travel decisions--trip frequency, modal choice, and destination choice. Note that this set of travel decisions is the behavior being modeled in step 4 above. Still other models calibrated with before and after data typically measure the difference in aggregate demand on a facility or system from a given improvement in level of service. However, if the before and after data are only for a specific facility, they include travel diverted to the facility from competing facilities as well as demand induced as a result of the facility improvement. Elasticities estimated by using such data do not distinguish between diverted and induced travel. The elasticity-based forecasting procedure described in this paper calls for separate calculation of induced and diverted travel components. That is, the transit trips factored to reflect induced travel consist only of trips already diverted to, or confronting, the benefits of the proposed transit improvement. Therefore, facility-specific data from before and after studies are generally inappropriate as sources of elasticities. In addition, elasticities that result from many before and after studies fail to fully account for the effects of changes in level-of-service that are exogenous to the improvement but that influence demand. In general, elasticities derived from models are preferred to before and after studies because they control for more factors that affect travel demand.

Elasticities are transferable contingent on certain conditions. Therefore, the elasticities to be used in patronage forecasting should be selected with several criteria in mind.

1. Elasticities should be derived from travel models that are consistent with travel behavior theory so that the elasticities will be behavioral.
2. Long-run elasticities should be used when future year travel forecasts are required. As discussed above, long-run elasticities can be estimated from cross-sectional (or some time-series) models that include (control for) a large set of relevant variables. Direct demand models (3,5) are preferred, especially for deriving nonwork trip elasticities because they measure at one time the impact of changes in all travel choices on ridership.
3. Elasticities should reflect the travel patterns of the study population to the extent possible by developing composite elasticities estimated for specific trip types or transit users. For example, the observed trip purpose distribution can be used to combine work and nonwork trip elasticities to develop the appropriate peak-period or all-day elasticity for the study area.
4. Socioeconomic characteristics of the population and the base level of service can have an effect on the value of elasticities. Therefore, elasticities appropriate for the study population and level of service should be used.

ELASTICITY-BASED PATRONAGE FORECASTS FOR BALTIMORE NORTH CORRIDOR

The Baltimore North Corridor alternatives analysis considered four basic transit alternatives: light rail, commuter rail, busway, and express bus. The light rail transit alternative consists of a new two-track rail transit system that would extend about 16.5 miles from the northern point of the corridor (Hunt Valley) through MetroCenter. The commuter rail alternative involves a shorter alignment that begins at Timonium (3.5 miles south of Hunt Valley) and ends near the northern border of MetroCenter. A timed transfer shuttle bus service provides collection and distribution service in MetroCenter. The busway consists of an exclusive right-of-way for buses used by two types of routes. A spine service is provided that originates at Hunt Valley, stops at intermediate on-line stations, and circulates on local streets in MetroCenter. Express buses, which provide park-and-ride and collection and distribution service in the North Corridor and circulate in MetroCenter, also use the busway. The express bus alternative consists of a network of park-and-ride lots and express bus services by using the existing roadway system in the North Corridor and circulating in MetroCenter.

Data Preparation

The elasticity-based method is predicated on the ability to identify and work (manually) with a relatively small number of existing routes and links from which travelers might be diverted to the new and improved facility. This is not usually possible when analyzing a new, high-speed expressway that profoundly affects travel on a large number of links in multiple corridors of a region. For the expressway example, detailed computerized conventional network analysis seems inescapable. However, such projects, which have such far-reaching facility interactions, are no longer the focus of most planning exercises. The Baltimore North Corridor transit alternatives are typical of current major transportation improvement proposals in even the largest urban areas. These consist of express transit lines whose travel impacts affect relatively few (albeit large) transportation links in one corridor.

Data preparation for the Baltimore North Corridor alternatives analysis included identification of the bus routes and links currently used that might be diverted to the new and improved facility. Volumes on these links are obtained from observed bus counts and represent the relevant travel universe that might be affected by the proposed alternatives. For purposes of growth factoring (step 1), it is necessary to define the area served by the affected transit links and to delineate analysis zones within the service area. The maximum service area was defined by examining the existing and proposed transit alternatives, their access characteristics, and relevant existing travel data such as data on distance between travelers' origins and transit lines and level of transferring. Because elasticities are applied incrementally, only travel affected by the alternatives needs to be considered. Therefore, data requirements are small relative to forecasting methods that simulate all travel in a region.

Trips on the affected transit links are then assigned to the origin and destination superzones served by those links. This assignment is done on the usual basis of shortest path (i.e., which bus routes serve which superzones), and information on average trip length or from on-board transit surveys if available. UTPS-selected link output, if available from an earlier study, is of course very helpful in this regard for obtaining the existing O-D distribution of observed trips on any transit link.

The actual travel diverted to each alternative is calculated in step 3 by using a proportional assignment procedure. The assignment procedure is based on the concept that the route choice travel decision can be represented as a function of the relative utilities or impedances on the alternate routes. The utilities are a function of the various service attributes, weighted by traveler's preferences for these attributes. Hence, the proportion of trips between two points attracted to each route is proportional to the relative impedances of the routes that connect these points, such that

$$P_i = (1/I_i)/\sum_j (1/I_j) \tag{1}$$

where

P_i = proportion of trips attracted to route i,
I_i = impedance of route i, and
i,j = route alternatives.

The impedance term includes level-of-service attributes such as in-vehicle time, walk time, wait time, and fare. The weights for attributes are derived from travel model coefficients estimated for populations comparable with the study corridor. The product of this step for each alternative (in the Baltimore application) is diverted travel by access mode to each station or express bus route segment by O-D pair and previous transit path. This allows the exact calculation of changes in most level-of-service characteristics faced by transit users to calculate diverted and induced travel. That is, the use of zonal average travel times or waiting times for multiple routes is avoided.

Calculation of the fourth travel component, induced travel, involves two steps. First, the percentage change in level of service faced by existing submodal travel markets is used to calculate increases in transit trips by these markets induced as a result of the improvement. Transit demand elasticities are applied to the service improvement obtained by users who travel between two zones for each base (previous) transit path and access mode. The separating of submodel travel markets avoids the need to aggregate access level-of-service over submodes (e.g., by taking weighted averages).

Aggregation introduces paradoxes and illogical change measures. For example, the bus paradox occurs when improved feeder bus to a trunk transit mode is provided in an improved alternative as a service improvement over park-and-ride and kiss-and-ride. Simple computation of a weighted average in-vehicle access time actually increases travel time with the service improvement since a higher percentage of transit users use the slower feeder bus relative to automobile access. This lowers overall demand for that route, despite the transit service improvement. Hence, the paradox, which is avoided by analyzing the behavior response of existing submodal travel markets separately.

The second step in the calculation of the fourth travel component is calculation of induced travel for new submodal travel markets. For example, with the provision of a park-and-ride station, travel by a new submodal market--automobile access--may be expected. In this case, if diverted and induced trips by walk and feeder bus at the new station are estimated to total 200 and the equilibrium submodal split at the station is 50 percent walk and feeder bus and 50 percent automobile, the station will attract 200 additional trips by automobile access for a total of 400 trips. Future equilibrium station assignment and access mode split depend on riders' origin distance from stations, available feeder bus, roads that connect origin zones and stations, parking availability, household income and automobile availability, and characteristics of the travelers' destination (e.g., parking availability). Access mode split is also heavily affected by the fact that transit travel between suburban areas where automobile level-of-service is good is dominated by transit captives, although travel to the downtown attracts choice riders as well as captives. Therefore, the origin-zone-specific access mode splits for travel to suburban destinations were significantly different from those assumed for travel to MetroCenter. The product of this step is total peak-period travel on the alternative. Note that because induced travel and diverted travel are calculated separately, a direct output of the method is the number of new transit trips associated with the transportation improvement.

Elasticities Selected for Baltimore

For the Baltimore alternatives analysis, elasticities derived from cross-section models (3,5-8) were used to develop constant peak-period transit elasticities. Elasticities with respect to the following transit level-of-service variables were developed: fare, in-vehicle time, out-of-vehicle time, and frequency. The frequency elasticity was used to measure the impact of changes in trip frequency where headways were greater than 10 min. The waiting time (out-of-vehicle time) elasticity alone is inadequate to measure the full effect on patronage of headways greater than 10 min because the conventional definition of wait time as one-half the headway up to a maximum of 5 min was used. Cross-elasticities with respect to the following automobile level-of-service variables were also developed: automobile operating cost and automobile in-vehicle time. The selected values for these elasticities are given in the table below.

Elasticity	Selected Value of Elasticity
Direct	
Transit fare	-0.15
Transit in-vehicle time	-0.37
Transit out-of-vehicle time	-0.65
Transit frequency	+0.26
Cross	
Automobile operating cost	+0.18
Automobile in-vehicle time	+0.20

Results

Total Baltimore North Corridor and MetroCenter peak-period (7:00-9:00 a.m.) transit trips are summarized for each alternative in Table 1. This table gives boardings on each alternative as well as all transit destinations in the North Corridor or origins in MetroCenter. The comparison of total transit trips reveals that the highest level of transit tripmaking occurs with the rail transit and busway alternatives, followed by express bus and commuter rail. The differences in the number of all corridor transit trips between alternative and base (1978 transit network) trips are new trips induced on each alternative.

COMPARISON OF ELASTICITY-BASED FORECASTS WITH UTPS FORECASTS FOR BALTIMORE NORTH CORRIDOR

Patronage forecasts for the alternatives were developed by using both the elasticity-based method and

Table 1. Daily morning peak period Baltimore North Corridor and MetroCenter transit trips by alternative, 1995.

Mode	Total Boardings	All Corridor and MetroCenter Transit Trips[a]	Difference in All Transit Trips Relative to Base[b] (%)
Base[c]		41 575	
Rail transit	14 147	46 560	+11.99
Commuter rail	4 197	42 332	+1.82
Busway	14 172	46 333	+11.44
Express bus	6 801	43 369	+4.32

[a] Includes all trips that have an origin or destination in the North Corridor or an origin in MetroCenter.
[b] Equals the percentage of new trips induced on each alternative.
[c] Refers to 1995 land use and highway system on 1978 transit network.

the local set of sequential travel demand models estimated by using UTPS software. Critical points of difference between the methods are described below.

STRUCTURAL AND CALIBRATION DIFFERENCES

The elasticity-based forecasting system is an incremental method in that changes in observed transit ridership are estimated as a function of changes in level-of-service. The four-step sequential forecasting procedure used to forecast patronage for the Baltimore alternatives, in contrast, is a synthetic method by which total regionwide transit travel is estimated from scratch for each alternative. Transit level-of-service and assignment are based on the minimum single transit path available (determined by the simple, unweighted sum of in-vehicle and out-of-vehicle time), including the minimum time access mode. Similarly, automobile level-of-service is measured on the single shortest path. Interzonal level-of-service variables included in the mode split model are in-vehicle travel time, out-of-vehicle travel time, and user cost. The resulting mode split is then applied to a fixed 1995 trip table. Transit trips are assigned to the network by using an all-or-nothing assignment procedure.

From the above descriptions, several critical differences with respect to the application of the two methods in Baltimore can be identified. First, the existing sequential models assume a fixed person trip table, but the elasticity method relaxes this assumption. Relaxation of the fixed trip table resulted in approximately 1000 additional trips in the case of rail transit. Second, transit level-of-service measures in the existing Baltimore mode split model are based on single minimum path level-of-service and, therefore, may present an optimistic measure of actual transit service used by all members of the public. The elasticity method, on the other hand, uses actual level-of-service faced by travelers on each transit path between a given O-D pair. The existing Baltimore assignment procedure involves all-or-nothing choice and is based only on travel time. The elasticity-based method diverts transit travelers by using a proportional assignment procedure based on several level-of-service variables. Note that the bias imposed by the use of minimum path level-of-service measures may be mitigated in that the coefficients of the existing mode split model were also estimated based on minimum path service measures. However, in many cases, the new facilities tested in this study provide significant service improvements, which leads to a greater difference between the minimum path and average path. Hence, this procedure results in upwardly biased estimates of transit travel.

The elasticity-based method also identifies distinct travel markets based on submodal choice, thereby avoiding the need to average level-of-service across submodes, which often leads to paradoxical results. In addition, this approach recognizes that automobile access to transit represents a distinct mode from walk or (feeder) bus access to transit and serves a different travel market segment. In the existing sequential models used, all transit modes are defined as a single mode that serves one travel market.

Finally, the two methods differ with respect to the level of calibration detail. Although the sequential method is applied at the transportation analysis zone level, the elasticity-based method employs sketch-planning zones. Therefore, the former method has the potential for measuring level-of-service with greater accuracy. The elasticity-based method, however, measures the changes in level-of-service exactly, based on travelers' submode and path for a given interzonal movement. The interzonal measures are used only as the large denominators in the calculations of percentage changes.

The impact of the structural and calibration differences identified above is that the sequential method is expected to result in larger diversions of automobile trips from the fixed trip table to the alternatives relative to the elasticity-based method. This is because of several optimistic assumptions regarding transit service employed in the sequential models, which are compounded in each step of the estimation procedure. In the first step, the minimum transit path is built. This pathbuilding results in an underestimate of actual transit travel time in three ways. First, not all transit users choose the path that has the minimum travel time. For example, automobile access may represent minimum access time, but not all users have an automobile available. Second, because the minimum pathbuilding method does not reflect that travelers weigh out-of-vehicle time more heavily than in-vehicle time, the model loads up new line-haul routes that minimize in-vehicle time relative to headways (wait time) and coverage (walk time). In addition, because the minimum path is both built and skimmed by using the unweighted sum of in-vehicle and out-of-vehicle time, the impact of a transfer between transit vehicles is underestimated, since a transfer imposes a higher proportion of out-of-vehicle time relative to total travel time. Similarly, cost affects travelers' route choice but is excluded in the building of the minimum path. Third, service frequency is excluded from the level-of-service measures. Because differences in frequency are important to travelers, the exclusion of frequency biases the patronage forecasts in favor of low frequency routes.

The above represent several of the major differences associated with the structural assumptions and calibration procedures of the two forecasting methods. Although the Baltimore application of UTPS is a very careful and elaborate procedure, a number of the assumptions reflect local practice rather than constraints imposed by UTPS software. For instance, some UTPS model sets build the minimum path based on a weighted sum of in-vehicle and out-of-vehicle time and cost. This definition of minimum path would reduce the error in the resulting patronage forecasts.

Total North Corridor boardings, inbound boardings, and the percentage of new trips estimated for each alternative by the two forecasting methods are compared in Table 2. (The boardings in Table 2 are lower than those in Table 1 because intra-Metro-Center trips are excluded for comparability with the available UTPS output.) Table 2 shows that the sequential models estimated with UTPS forecast a larger number of total boardings for all alternatives. The average difference between forecasts of total North Corridor boardings shown in Table 2 for the two methods is 41.4 percent. The average difference between forecasts of inbound boardings, however, is only 17.2 percent, which indicates that the greatest difference lies in outbound trips. The share of morning peak-period outbound trips forecast by the sequential method ranges from 45.1 percent for rail transit to 51.7 percent for commuter rail. The elasticity-based estimates of outbound trips ranges from 25.4 percent for commuter rail to 32.1 percent for rail transit.

The 1995 base transit trip table developed by using the elasticity-based method revealed about 25 percent outbound trips and the UTPS trip table revealed about 35 percent outbound trips. A higher

Table 2. Comparison of elasticity-based and UTPS Baltimore North Corridor patronage results by alternative, 1995.

	Elasticity-Based Method Boardings		UTPS Boardings	
Alternative	Total	Inbound	Total	Inbound
Rail transit	13 638	9262	18 508	10 168
Commuter rail	4 106	3063	8 828	4 268
Busway	11 182	8033	12 998	6 383
Express bus	5 587	3888	7 502	3 931

Note: Patronage refers to 1995 daily peak-period (7:00-9:00 a.m.) trips, excluding intraMetroCenter trips for comparability with available UTPS output.

proportion of outbound trips on the new alternatives is reasonable since the improvement in level-of-service relative to the base transit network is greater in the outbound direction; however, the share of outbound trips forecast by the sequential method is exaggerated. A principal reason for this is that, as noted earlier, the four-step sequential procedure used in this application underestimates the impact of a transfer. In the case of commuter rail, which has relatively long headways, this upward bias in favor of the new transit alternative is maximized.

Table 2 also indicates that the sequential method estimates fewer inbound busway boardings than does the elasticity method. Two major factors account for this difference. First, the provision of high-quality park-and-ride service under the busway alternative attracts a significant number of park-and-ride passengers. As noted previously, the elasticity method treats a new access mode as a new travel market, and the sequential method simply assigns a fixed number of transit riders to the minimum path access mode. Second, the elasticity method will estimate a greater number of new trips, all else being equal, because a fixed total trip table is not assumed.

The results of the two methods are also similar in several important ways. First, the light rail and busway alternatives attract considerably more trips than do the commuter rail and express bus alternatives in both methods. Second, a significant share of North Corridor boardings occur at the stations within Baltimore City where the population density is higher and incomes and automobile ownership are lower (relative to stations in Baltimore County). Finally, a significant minority of outbound trips are destined for the Towson area, an employment and population center in Baltimore County. These similarities increase our confidence in the patronage forecasts. In addition, our ability to explain differences in the forecasts based on assumptions implicit in the methods increases our confidence in the validity of the elasticity-based approach. [Note: the elasticity-based figures are being used as the final patronage results for local and Urban Mass Transportation Administration (UMTA) decisionmaking purposes in this UMTA-sponsored alternatives analysis.]

ADDITIONAL APPLICATIONS OF THE ELASTICITY-BASED METHOD

The Baltimore alternatives analysis patronage forecasting work represents one of the most complex applications of the elasticity-based method. The multitude of modest alternatives currently being considered in urban transportation clearly need easy-to-use forecasting methods for assessing their travel consequences. The forecasting methods should be subject to strict reasonableness tests. The validity of the results suggests that the method can be even more easily applied to transportation alternatives that have fewer network analysis requirements (e.g., requirements that affect travel on fewer existing links with fewer submodes.) Other applications of the method include estimating the ridership response to improvements in existing transit routes; determining the travel impacts of highway improvements and other automobile level-of-service changes, including parking strategies and gasoline price changes; and determining the optimum mix of fare and service changes for maximizing transit revenues.

The elasticity-based method provides a quick-turnaround, relatively inexpensive alternative to conventional large-scale travel models. The method saves personnel and computational resources without sacrificing accuracy. It relies on easily available ground count data and can be applied manually or with the use of simple computers. Also, the structure of the method is easily understood by transportation planners and its transparency allows the analyst to determine the impact of each step of the estimation procedure on the resulting forecasts.

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