Modified Simulation Technique for Mode-Choice Analysis

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The Delaware Valley Regional Planning Commission (DVRPC) is the agency responsible for the development and maintenance of regional travel demand forecasting models for the bi-state Philadelphia metropolitan area. The nine-county region, with a 1970 population of 5.2 million people living in an area of 9926 km² (3833 miles²), is the fourth largest metropolitan area in the nation.

The regional transportation system is a highly developed and completely interrelated network of transit and highway facilities whose present configuration is the result of nearly three centuries of growth. It is estimated that in 1970 this system was required to serve the travel needs of nearly 12 million person trips on an average day.

Travel demand estimation for large, complex metropolitan areas is a very resource-consuming effort. The computer time cost and work hours of effort to apply the standard DVRPC simulation process make such application in some studies unreasonable. Yet, the level of detail in the standard process may be quite appropriate for that study. It was the intention of DVRPC to develop a technique that would utilize as much of the standard simulation modeling process as possible with the greatest reduction of cost. One such technique, referred to as the modified simulation technique (MST), is discussed here. To properly set the context of MST, the standard DVRPC simulation process will first be described.

STANDARD DVRPC SIMULATION PROCESS

The DVRPC travel demand modeling concept (1) follows the traditional four-step process: trip generation, trip distribution, mode choice, and trip assignment (Figure 1). The trip generation (step 1) uses a disaggregate trip rate model. This step requires extensive knowledge of the magnitude and location of regional activities such as land use, employment, and the demographic characteristics of the resident population. Trip distribution (step 2) uses a typical gravity formulation stratified by trip purpose. The separation variable in the DVRPC model is a composite highway and transit travel time.

The third step of the travel-forecasting process, mode choice, estimates the proportion of the trips between two zones that will use the transit system and the proportion that will use the highway system. Figure 2 is a more detailed diagram of step 3. The diagram shows that there are three tasks (A, B, and C) that must be performed for both transit and highway prior to the estimation of mode trips. Task A, code/edit networks, involves describing in numerical terms every link in the two networks [over 40 000 links on more than 13 300 km (8300 miles) of facilities]. In addition, the levels, types, and interrelationships of the service provided by the transit network must also be numerically described.

Task B within the mode-choice estimation (step 3) is the determination of the "best" path (a successive combination of links) between every pair of zones in the region (1342 zones, roughly 1.8 million pairings for both the highway network and the transit network). In the DVRPC process, the best path is defined as the one that costs the least to take. Cost is actually the sum of the dollar value of perceived time and out-of-pocket cash. This type of cost is felt to describe the network's resistance to free flowing, instantaneous travel and is referred to as the impedance to travel. In task C, the component parts of this impedance are skimmed off the network and cataloged.

Task D, the estimation of transit mode and highway mode trips from the person trips of step 2, requires knowledge of the available transportation system (supply), knowledge of the flows to be handled by that system (demand), and knowledge of the environment in which the demand will seek satisfaction from the supplied system. This environment includes the social, economic, and policy aspects of urban activity and their spatial orientations. The mode-choice estimating model relates this knowledge to predicting the percentage of trips likely to use the transit mode and the percentage likely to use the highway mode. The multiplication of these percentages by the person trips from step 2 yields the person trips on each mode. The DVRPC mode-choice estimating model is a post-distribution, stratified diversion curve formulation that primarily relates differences in highway and transit travel time and cost to mode percentages. The stratifications are by trip purpose, principal transit submode of best travel path, and auto availability.

The final step of the standard (DVRPC) simulation process (step 4) is the assignment of the various types of trips to the transportation system networks.

MODIFIED SIMULATION TECHNIQUE

The modified simulation technique (MST) is applicable to the study of changes in mode choice resulting from changes in service level, skip-stop or express service, station spacing, and shifts in route alignment. The underlying assumption is not that the primary transit route or mode route does change, but that the specific links of the path might change. The primary impact of these service changes will be in the level of transit mode choice for a given trip interchange.

The MST procedure is as follows: first, the standard regional simulation process is run with the transit facility fully coded into the network as a base case; second, the impedance catalog is modified to reflect the service changes embodied in each alternative to be studied; and, third, the mode-choice model (step 3, task D) is rerun for each alternative. The heart of the MST lies in how the impedance catalog is modified. Figure 3 shows the flow of effort in the MST.

Subtask 1 (determine station geographic market area) uses the data file on best transit paths to identify station market areas. Using the UTPS program USTOS and a special DVRPC program STATMKTS, a zone-to-station correspondence table is constructed. This table identifies the transit line station used by each zone in the base case.

Subtask 2 (redeline station market area) requires the analyst to examine the description of the alternative
Figure 1. DVRPC standard simulation process.

Figure 2. Standard simulation mode-choice process.
and the zone-to-station correspondence table and decide for each zone the station of choice under the conditions of the alternative. This task relies on the experience of the analyst and his or her familiarity with the service areas and travel behavior.

Subtask 3 (modify impedances) is divided into three potential levels of impedance modification. Level 1 accounts for the change in impedance resulting from any redefinition of the station market areas. Typically this level of modification occurs when a station is removed from the base case line. Trips that formerly used the removed station must use stations closer to or farther from their destinations, resulting in longer or shorter trips. The level 1 impedance change will be plus or minus the difference in running time between the old and new station of choice. Level 2 accounts for the changes in trip impedance resulting from changes in the line-haul operation that change interstation running times or station waiting times. Level 3 accounts for changes in impedance resulting from longer or shorter approach trips to the transit station. This type of change occurs when stations are removed from consideration or when the horizontal alignment of the line changes. Some changes may also require a change in approach mode and additional fare payments.

DVRPC has written a computer program, MODTIMPD, which reads in the zone-to-station correspondence table, the interstation impedance change matrix, the station reassignment table, and the trip-end access and egress impedance change table along with the skimmed impedance catalog. The output of the program is a modified impedance catalog. This modified impedance catalog is supplied as input to the mode-choice model for each alternative. The zone-to-station correspondence table can be used to reformat the new transit trip tables to get an interstation volume matrix.

CONCLUSION

The modified simulation technique does provide a useful and cost-effective means around the expense of the standard simulation process. Of course, its applicability is limited to those studies where the underlying assumption of "no significant change in primary transit submode route" is considered a reasonable approximation. The procedure has been used by DVRPC for the screening of preliminary alternatives in the city of Philadelphia study of replacement alternatives for the Frankford Elevated rapid transit line (2).

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REFERENCES


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