Introducing "Feedback" into Four-Step Travel Forecasting Procedure Versus Equilibrium Solution of Combined Model

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The manner in which the solutions produced by various methods of introducing "feedback" into the four-step travel forecasting procedure compare with the equilibrium solution of a model combining the trip distribution, mode split, and assignment steps was examined. The comparisons were performed on a sketch-planning model of the Chicago region with about 300 zones and 3,000 highway links. From these comparisons one can learn that iterating the four-step procedure in an ad hoc manner does not produce the desired result. Instead one needs to apply an algorithm designed to converge to a well-defined equilibrium of the travel flows and the link times and costs determined by these flows. Progress in improving travel forecasts will not result from calls for solving the four-step procedure with feedback. Rather progress will be made as professional practitioners begin to understand the requirements of the desired equilibrium solutions. Then they must insist that their software developers correctly implement the algorithms required to compute these solutions. Finally they should insist that FHWA short courses introduce participants to contemporary solution methods that yield the desired equilibrium properties. Likewise university instructors and textbook authors should update their courses to produce a new generation of professionals who understand the principles of equilibrium travel models.

At the 1993 TRB Annual Meeting FHWA staff spoke about "feedback" in the context of the four-step travel forecasting procedure. In discussing their concerns with metropolitan planning organization staff we began to understand that this call for feedback was essentially an admission that the four-step procedure is inadequate to the task of predicting origin-destination, mode, and route choices in a congested, multimodal urban transportation network. Because they were not sure what to do about this inadequacy and because they were mired in the paradigm of the 1960s, they were calling for the solution of the 1960s: iterate the four-step procedure until the link flows, their associated generalized travel costs (impedances), and the corresponding origin-destination-mode choices are brought into a consistent relationship with each other.

The first author of this paper, having entered the urban transportation planning field in about 1960, remembers well the efforts of early modelers to define what they meant by feedback and convergence in the emerging four-step procedure. In the course of interviewing the staffs of various metropolitan planning agencies in 1968 for his book, *Metropolitan Plan Making* (*1*), he recalls asking whether they had ever succeeded in iterating their travel forecasting procedure, that is, resolving the four-step procedure by using the travel times yielded by the trip assignment step. The answer was universally no. Neither they nor he had considered what nonsense would have resulted had they attempted such a rough approach.

Since becoming aware of the formulations of Evans (*2*) and Florian et al. (*3*) in mid-1976, the first author rarely thought about feedback in the above sense until January 1993. Instead he has devoted the past 17 years to implementing, evaluating, and calibrating various models, mainly for the Chicago region, which are guaranteed by their formulation and solution method to converge to the *equilibrium* solution that is still characterized by the obsolete term *feedback* [see Boyce et al. (*4–6*), Boyce and Lundqvist (*7*), Boyce (*8*), and Lee (*9*)]. Putman (*10*) has applied the same concept to a small test problem as well as to larger-scale problems.

Since it is apparent from the above remarks that the four-step procedure is finally viewed as inadequate, we thought it would be best to try to demonstrate what difference a convergent algorithm makes to the solution of travel choice models. By comparing those results with various approximate solutions used in practice, we hope to convince professional practitioners once and for all of the merits of the Evans partial linearization algorithm for solving combined models of trip distribution, mode choice, and assignment or, as we prefer to say, equilibrium models of origin-destination, mode, and route choice.

What are the characteristics of these equilibrium models that we find so appealing? In fact they are the same characteristics that we seek for the four-step procedure, but that are rarely seen in print, and were certainly not understood by the agency staff who originally proposed the four-step procedure in the 1960s [see for example Carroll (*11*)]. The two equilibrium conditions that we require may be simply stated as follows:

1. The generalized travel costs from each origin zone to each destination zone by automobile equal the sums of the individual link costs over the used routes; no unused route has a lower cost; the link costs depend in part on the link flows resulting from the trips per hour by automobile between all origin-destination pairs.
2. The number of trips per hour from each origin zone to each destination zone by each mode depends on the generalized travel costs determined in part by the automobile link flows resulting from those trips.

Perhaps Beckmann et al. (*12*) put it best, as well as first: "The prevailing demand for transportation, that is the existing pattern of origins and terminations, gives rise to traffic conditions that will maintain that same demand." Unfortunately almost no one in this field, including the first author, was aware of their fundamental contribution to our field when it was so greatly needed in the late 1950s.

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The intended contribution of this paper is not to describe in detail the Evans partial linearization algorithm for solving equilibrium models, which produces solutions that are guaranteed to converge to the above conditions. That has been done elsewhere (*5,6,13*); however, the method is described below in terms familiar to practitioners. Rather the intent is to compare the results of this method with various solution techniques used at present and in the past that are *intended* to converge to the desired conditions. These techniques are a sampling of possible iterative approaches and are intended to be illustrative. The objective of all of the approaches is the same: to find the solution that satisfies the equilibrium conditions. Some methods can be proven to converge to these conditions; others cannot. The issue is which ones do converge and how quickly do they achieve an acceptable level of convergence?

Following a statement of four solution techniques, as well as the Evans algorithm, the results of solving a large-scale model with each method are compared. The variables used in this comparison are highway link flows, automobile and transit trip tables, and automobile generalized costs; transit generalized costs are a fixed input to all the methods and hence do not vary. The solution variables are compared with a highly converged solution of the model, which may be regarded as the "true" solution. Such a highly converged solution would not usually be computed in practice, and hence serves as a standard for comparing the various methods.

The paper concludes with the authors' recommendations concerning what steps should be taken to implement the use of equilibrium models in professional practice.

COMPARISON OF SOLUTION METHODS

In this section we describe the five solution procedures applied in our experiments. First, we describe the variants of procedures based on traditional practice. Four procedures were defined. In each procedure an estimate of the automobile generalized travel cost matrix and the fixed transit generalized cost matrix are inputs to the trip distribution model. Following the Chicago Area Transportation Study practice of using an automobile travel cost matrix for the most similar network available, we used the matrix from the fifth iteration of the Evans algorithm described below. This choice gives each procedure a highly advantageous starting point.

Method 1: One Iteration of Trip Distribution, Mode Split, and AON Assignment

We begin with the simplest possible choice, one iteration of the four-step procedure with all-or-nothing (AON) assignment as the assignment method. Although this procedure is believed to be completely inadequate, it does provide one simple result for comparison with other methods. The procedure is illustrated in Figure 1(*a*) with one iteration.

Method 2: Multiple Iterations of Trip Distribution, Mode Split, and AON Assignment

This procedure is the simplest concept of feedback: simply iterate through the four-step procedure several times; the travel costs determined by the assignment step form the basis for the next trip distribution and mode choice. This procedue is also believed to be unsuitable; again we include it for comparative purposes. Method 2 is also illustrated by Figure 1(*a*).

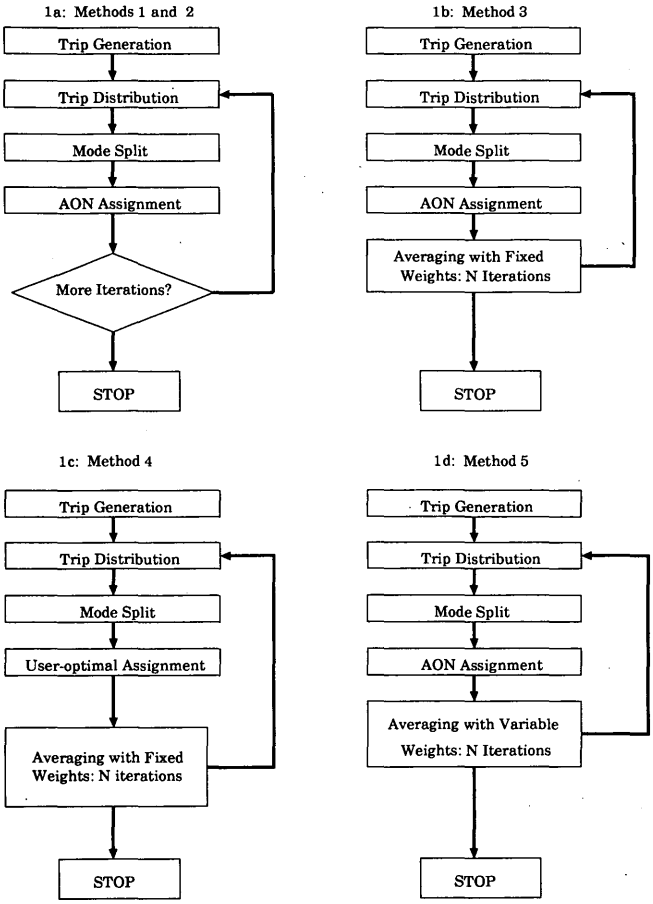

FIGURE 1 Comparison of solution procedures: (*a*) Methods 1 and 2, (*b*) Method 3, (*c*) Method 4, and (*d*) Method 5.

Method 3: Multiple Iterations of Trip Distribution, Mode Split, and AON Assignment with Averaging at Each Iteration

This procedure is the similar to the previous one except that the origin-destination-mode matrix and the link flow vector are averaged together after each solution of the four-step procedure. The weights are chosen as follows:

1. The first solution results from one iteration of the four-step procedure (same as Method 1 above).

2. The second solution, which is based on the travel costs of the first solution, is averaged with the first solution with equal weights (50/50).

3. The third solution, which is based on the average of the first two solutions, is weighted one-third and the former solution is weighted two-thirds (67/33).

n. The *n*th solution, which is based on the result of iteration $(n - 1)$, is weighted $(1/n)$ and the former solution is weighted $(n - 1)/n$.

Note that in each solution each of the previous solutions is weighted equally; moreover at each iteration the combined results from the previous solutions provide the inputs to the four-step procedure. This method is somewhat like the Bureau of Public Roads capacity-restrained assignment; in that procedure, however, the link-flow vectors were averaged only as the conclusion of several iterations.

Method 3 is known in the transportation science literature as an iterative technique that uses predetermined step sizes or the method of successive averages. Under the conditions that are satisfied here, the method is known to converge to the desired equilibrium solution [see Sheffi (*14*,p. 324)]. However convergence may be quite slow. Method 3 is shown in Figure 1(*b*).

Method 4: Multiple Iterations of Trip Distribution, Mode Split, and User-Optimal Assignment with Averaging at Each Iteration

This method is similar to Method 3 except that the AON assignment is replaced by a user-optimal assignment with five iterations. User-optimal assignment, as performed by the Frank-Wolfe or linearization method, consists of the following steps:

1. Perform an AON assignment of the automobile trip matrix to the automobile network;
2. In the first iteration designate the resulting link-flow vector as the current solution and return to step 1; in the second and successive iterations determine a weight for averaging the AON link-flow vector with the current solution (weighted average of previous AON link-flow vectors) such that the resulting vector is as close as possible to the user-optimal conditions for a fixed automobile trip matrix, as judged by a function of the new current solution; and
3. Check convergence and continue if the algorithm has not adequately converged; in this application the procedure was terminated after five iterations (AON assignments and averaging steps).

Feedback can be introduced by repeating this four-step procedure a second, third or fourth time. To ensure convergence the results of these iterations should be averaged together by applying the method of successive averages described under Method 3. Otherwise the results tend to oscillate.

Since each sequence of this four-step procedure involves five AON assignments, the computations for one iteration of Method 4 are roughly comparable to five iterations of Methods 2, 3, or 5. Method 4 is illustrated in Figure 1(*c*).

The four methods described above are intended to represent methods used in conventional practice. Next we turn to a description of an efficient, convergent algorithm for solving the equilibrium problem described earlier. At this point it may be helpful for the reader to think of the problem to be solved as the *underlying* equilibrium problem and to regard the traditional four-step procedure as a relatively crude solution method, or heuristic. In other words the problem we are seeking to solve is not some embellished version of the four-step procedure; rather we seek a solution that satisfies the two conditions stated earlier.

Method 5: Evans Algorithm

The algorithm described below is a partial linearization method, in contrast to the full linearization, or Frank-Wolfe, method mentioned above. We also refer to it as the *Evans algorithm* after its originator, Suzanne P. Evans (*2*). The method may be described informally as follows:

1. Solve the trip distribution and mode split steps of the four-step procedure, given an initial automobile travel cost matrix, as well as the fixed transit cost matrix;
2. Perform an AON assignment of the automobile trip matrix to the automobile network;
3. In the first iteration, designate the trip matrices and link flow vector from Steps 1 and 2 as the current solution and return to Step 1; in the second and successive iterations determine a weight for averaging the trip matrices and the link-flow vector from Steps 1 and 2 with the current solution, such that the resulting matrices and vector are as close as possible to the equilibrium conditions described in the first section, as judged by a function of the new current solution (trip matrices and link-flow vector); and
4. Check convergence by a measure defined on the current solution and the results of Steps 1 and 2 and continue if the algorithm has not adequately converged.

The above method is the same as Method 3 except that the weights used in the averaging steps are not predetermined but are chosen to be the best at each iteration. A well-defined convergence measure is available on the basis of the calculation of the greatest lower bound on the objective function of the equivalent optimization problem at each iteration. This measure is very useful in monitoring the convergence and in comparing the convergence of solutions of alternative plans [see Figure 1(*d*)].

In the results that follow the solutions of the model computed with the Evans algorithm with 5, 10, 15, and 20 iterations are compared with those computed by Methods 1 to 4. Each of the solutions is compared with a "true" solution of the model computed with the Evans algorithm with 50 iterations. In this solution the objective function is no more than 0.2 percent from the optimal value desired for all methods, a very highly converged solution. Of course such a solution would not be utilized in practice; it is used here only to provide a basis for evaluating all of the methods. The "true" solution could also have been computed by Method 3 or 4 or any convergent method; we used the Evans algorithm because it is more efficient than Method 3 or 4.

Each of the methods described above was solved for a sketch-planning model of the six-county Chicago region. The model is based on a highly aggregated zone system, with 317 zones of 14.5 and 58 km^2 (9 and 36 mi^2) each and about 3,000 highway links. The trip distribution and mode split model are a single exponential (logit) function doubly constrained to satisfy fixed trip ends. All trip purposes are combined in the single function. Transit choice is based on fixed matrices of transit in-vehicle times, waiting and transfer times, plus a transit fare matrix. The submodes of bus, rapid transit, and commuter rail are represented in one matrix generated from a single transit network. Automobile person trips are converted to automobile vehicle trips on the basis of an average occupancy factor and are assigned to the aggregated automobile network; a separate matrix of equivalent truck trips is also assigned. The generalized cost and trip deterrence parameters were calibrated from matrices based on the 1980 Census and survey data. The generalized cost parameters include a transit bias term that results in an accurate prediction of regional mode split. The predicted mode split for transit trips to the central business district is within 5 percent of the observed value. Additional details and sensitivity analyses may be found in Boyce et al. (*6*).

ANALYSIS OF RESULTS

In this section we present the results of the solutions of the five methods described previously. The results are presented in the form of a table for each of the four variables (link flow, auto and transit trips, and auto generalized costs). Each table compares the solution for each method (*M*) with the highly converged or true solution (*T*) by using the following measures:

$$\text{Root mean square error (RMSE):} \quad \left[\sum_{i}^{m} (M_i - T_i)^2/m\right]^{1/2} \qquad (1)$$

$$\text{Chi-square:} \quad \sum_{i}^{m} \left[\frac{(M_i - T_i)^2}{T_i}\right] \qquad (2)$$

With R^2 for a regression with M as the dependent variable and T as the independent variable.

The data elements are the pairs of origin-destination-mode combinations or the pairs of links; m is the number of data elements with positive values. Zero values in the solutions were removed, since these values are a property of the model formulation or the data rather than the solution method.

For these measures the desired results are as follows:

1. The values of RMSE and chi-square should be zero;
2. The value of R^2 should be 1.

In each table the results for Method 1 and Methods 2 to 5 for five iterations are presented first. Then the results for Methods 3, 4, and 5 for 10, 15, and 20 iterations are compared. Note that the result of Method 1 is also the initial solution for Methods 2 to 5, and hence serves as a basis for comparing Methods 2 to 5 after five iterations.

Next the results are illustrated with two sets of four plots each for link flows and one set each for the other variables. The first set of link-flow plots corresponds to Methods 2 to 5; the second set is for Method 5 with 5, 10, 15, and 20 iterations. Link flows are examined in more detail because this variable is the slowest to converge.

Results for Automobile Link Flows

The first five rows of Table 1 show the results for the five methods with five iterations except for Method 1. The results for the first two methods are clearly unacceptable. Methods 3, 4, and 5 are rather similar; recall that Method 3 consists of five iterations of trip distribution, mode split, and AON assignment with predetermined weights, Method 4 is one solution of the trip matrices and five iterations of user-optimal assignment, and Method 5 consists of five solutions of the trip matrices and five AON assignments. Although the results of Methods 3 and 5 have better RMSEs, Method 4 has a better chi-square value. Hence the results of these three methods are quite similar. Both RMSE and chi-square are very effective in comparing the solutions with the true solution; however, R^2 is largely ineffective except for Methods 1 to 2, which are clearly very poor.

TABLE 1 Results of Five Methods for Automobile Link Flows

Method	Iteration	RMSE	Chi-sq	R-sq
1-5	1	2052	1884910	.56
2	5	5304	10199398	.44
3	5	386	464700	.84
4	1×5	428	230588	.92
5	5	358	504876	.98
3	10	194	116300	.98
4	2×5	333	196623	.98
5	10	310	87004	.98
3	15	125	49530	.99
4	3×5	293	181810	.98
5	15	145	21952	.99
3	20	85	26240	.99
4	4×5	244	146877	.98
5	20	77	7461	.99

number of links with positive flow - 2,767

Rows 6 to 8 of Table 1 compare two iterations of Method 4 with 10 iterations of Methods 3 and 5. Since these three methods involve 10 AON assignments, the computational effort is roughly comparable. Table 1 shows that Method 4 (2 × 5 iterations) converges only slightly from the 1 × 5 solution, whereas Methods 3 and 5 (10 iterations) continue their convergence. The RMSE and chi-square values for the Evans algorithm decrease more than for Methods 3 and 4 as the number of iterations increases (see rows 9 to 14 of Table 1). The convergence is more pronounced for chi-square than for RMSE.

Turning to Figures 2 and 3 one can observe that Method 2 produces unacceptable results by comparing the link flows for each method on the *y*-axis with the "true" values on the *x*-axis. The results for Methods 3, 4, 5 are much closer to the 45-degree line, although Method 3 is much more dispersed than Methods 4 and 5. These results illustrate why scatter diagrams are essential in addition to measures such as RMSE and chi-square. Figure 3 shows the plots for higher numbers of iterations of the Evans algorithm (Method 5). The clustering around the 45-degree line becomes more and more pronounced as the number of iterations increases.

Results for Automobile Trips

For the automobile and transit trip matrices the results for Methods 1 and 4 (1 × 5) are the same, since both are based on the initial matrix of generalized automobile costs. Both sets of measures are rather large in comparison with Methods 3 and 5, which involve solving the trip matrices five times. In Table 2 Method 2 is seen to be unacceptable, but Method 3, the predetermined step size method, is relatively good but is always inferior to Method 5. Examination of Method 4 shows that the method converges, but not as rapidly as Methods 3 and 5. Figure 4 also shows that Methods 2 and 4 are inferior to Methods 3 and 5.

Results for Transit Trips

Since transit trips are based on fixed generalized costs in our model they depend only indirectly on the equilibrium automobile costs. Nevertheless Methods 3 and 5 clearly produce superior re-

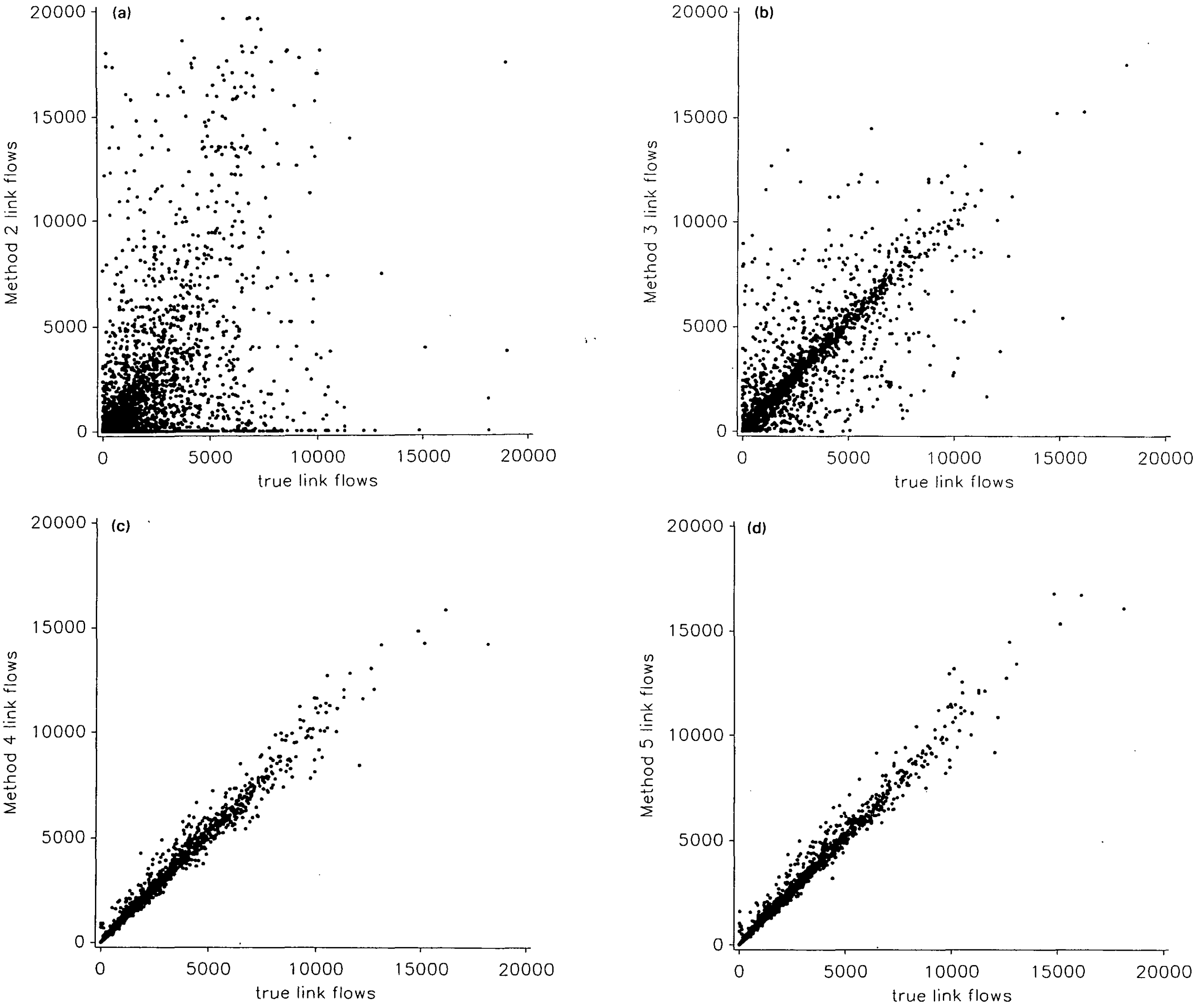

FIGURE 2 Results for link flows (Methods 2 to 5): (*a*) Method 2, (*b*) Method 3, (*c*) Method 4, and (*d*) Method 5.

sults compared with those produced by Methods 1, 2, and 4 (see Table 3). Method 4 does converge, but more slowly than Methods 3 and 5. Figure 5 shows that Method 5 produces slightly better results than Methods 3 and 4; as before Method 2 is clearly unacceptable. Note that here, as with automobile trips, the plot for Method 1 would be identical to the plot for Method 4.

Results for Automobile Generalized Costs

Table 4 for automobile generalized costs shows a pattern similar to those in Tables 2 and 3. Methods 1 and 2 are clearly inferior. Method 4 (1 × 5 iterations) is the next largest; this is followed by Methods 3 and 5. Method 4 converges, but not nearly as much as Methods 3 and 5 for 10, 15, and 20 iterations. The plots for these solutions, shown in Figure 6, are rather similar for Methods 3, 4, and 5, which show much better convergence than Method 2.

Results for Selected Regional Attributes

One important question raised about an earlier version of this paper is, "Does the choice of method make a difference in an important model output variable like vehicle kilometers of travel (VKT)?" We had to admit that we did not know the answer to this important question, but we decided to find out. The results are presented in Table 5.

From several regional attributes computed by our code we selected highway vehicle kilometers of travel, mean automobile travel time, automobile space-mean-speed, and percentage of trips by transit. Central processing unit (CPU) time is also included. The results were quite surprising to us, and therefore well worth presenting. We know from Tables 1 to 4 that the choice of method does lead to important differences in measures comparing differences in the model outputs at the link or zone pair level. At the regional level, however, the aggregated

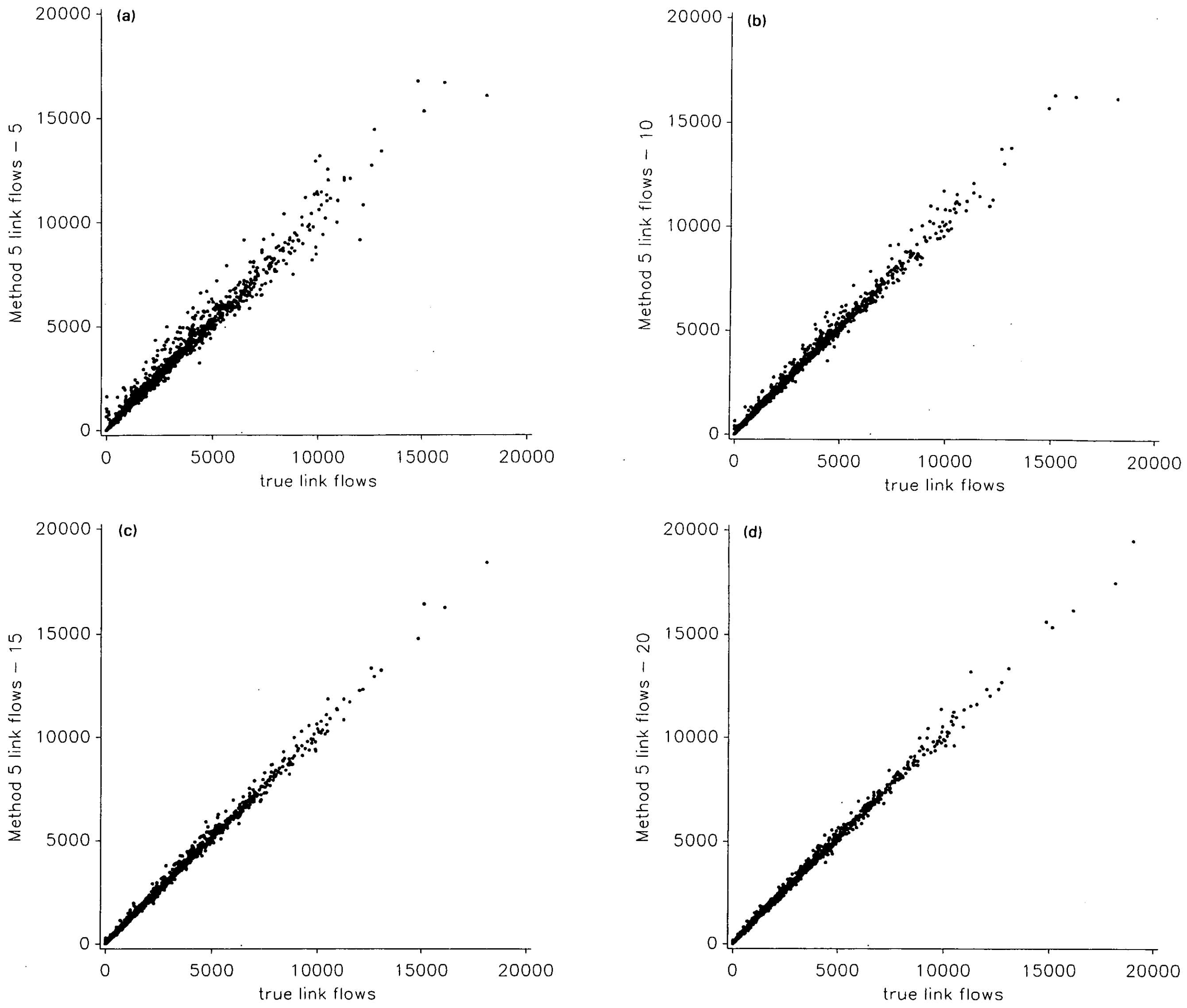

FIGURE 3 Results for link flows (Method 5): (*a*) 5 iterations, (*b*) 10 iterations, (*c*) 15 iterations, and (*d*) 20 iterations.

TABLE 2 Results of Five Methods for Automobile Trips

Method	Iteration	RMSE	Chi-sq	R-sq
1-5	1	7.38	9352	.99
2	5	28.25	338734	.86
3	5	4.48	4510	.99
4	1×5	7.38	9352	.99
5	5	3.78	3015	.99
3	10	4.48	1629	.99
4	2×5	3.94	3677	.99
5	10	1.80	645	.99
3	15	1.85	746	.99
4	3×5	3.30	3039	.99
5	15	1.25	292	.99
3	20	1.40	416	.99
4	4×5	3.11	2632	.99
5	20	.84	147	.99

number of positive O-D flows - 72,630

model attributes are essentially the same for Methods 3, 4, and 5. Method 2, which is not a convergent method, yields unacceptable values however. We also observed, but do not report here, that Method 4 does diverge if the averaging step is omitted.

What these results indicate, then, is that any method that can be shown to converge to the true solution should yield reasonably good values of regional attributes. Recall, however, that there is no established concept of *convergence* as a requirement for the four-step procedure. Hence "Use a convergent method" is the proper response to the question, "How do I introduce feedback into the four-step procedure?"

Although the differences are small, the reader may notice that Method 5 is slightly superior to Methods 3 and 4 for 10 or more iterations for the regional attributes presented. The additional computing effort needed to obtain this result is a one-third increase over Method 4.

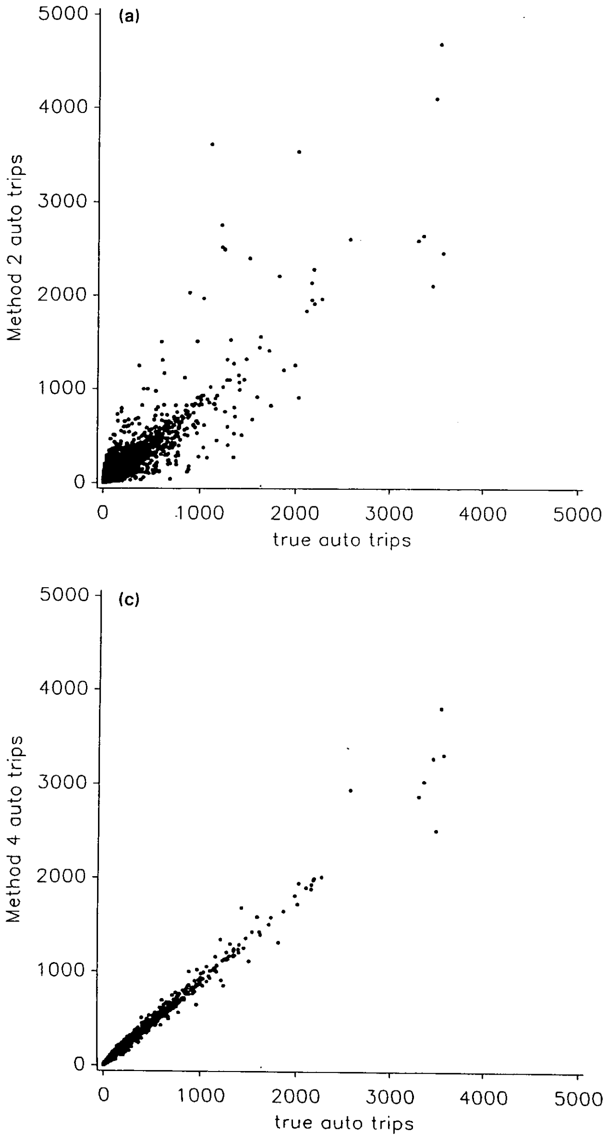

FIGURE 4 Results for automobile trips (Methods 2 to 5): (*a*) Method 2, (*b*) Method 3, (*c*) Method 4, and (*d*) Method 5.

TABLE 3 Results of Five Methods for Transit Trips

Method	Iteration	RMSE	Chi-sq	R-sq
1-5	1	4.28	934	.99
2	5	25.39	22992	.96
3	5	1.23	92	.99
4	1×5	4.28	934	.99
5	5	1.05	52	.99
3	10	.79	37	.99
4	2×5	.81	58	.99
5	10	.58	19	.99
3	15	.52	18	.99
4	3×5	.76	45	.99
5	15	.47	10	.99
3	20	.38	11	.99
4	4×5	.82	39	.99
5	20	.36	6	.99

number of positive O-D flows - 55,141

CONCLUSIONS

Although it is recognized that these results are quite aggregated, we hope that they provide substantial insights into the performance of various methods, both ad hoc and convergent, for solving the travel forecasting procedure in an iterated manner. Although this is not the place for mathematical justifications of the Evans algorithm, we trust that the computational results produced by Method 5 are also convincing because they do converge to the desired equilibrium. What is equally important is that the computational effort for Method 5 is similar to those for Methods 2 and 3 and only slightly more onerous than that for Method 4. A time-saving variant of Method 5 is to update the trip matrices at every third or fifth iteration rather than at every iteration. The total number of iterations required for Method 3, 4, or 5 depends on the desired convergence. At least five iterations are necessary for congested networks.

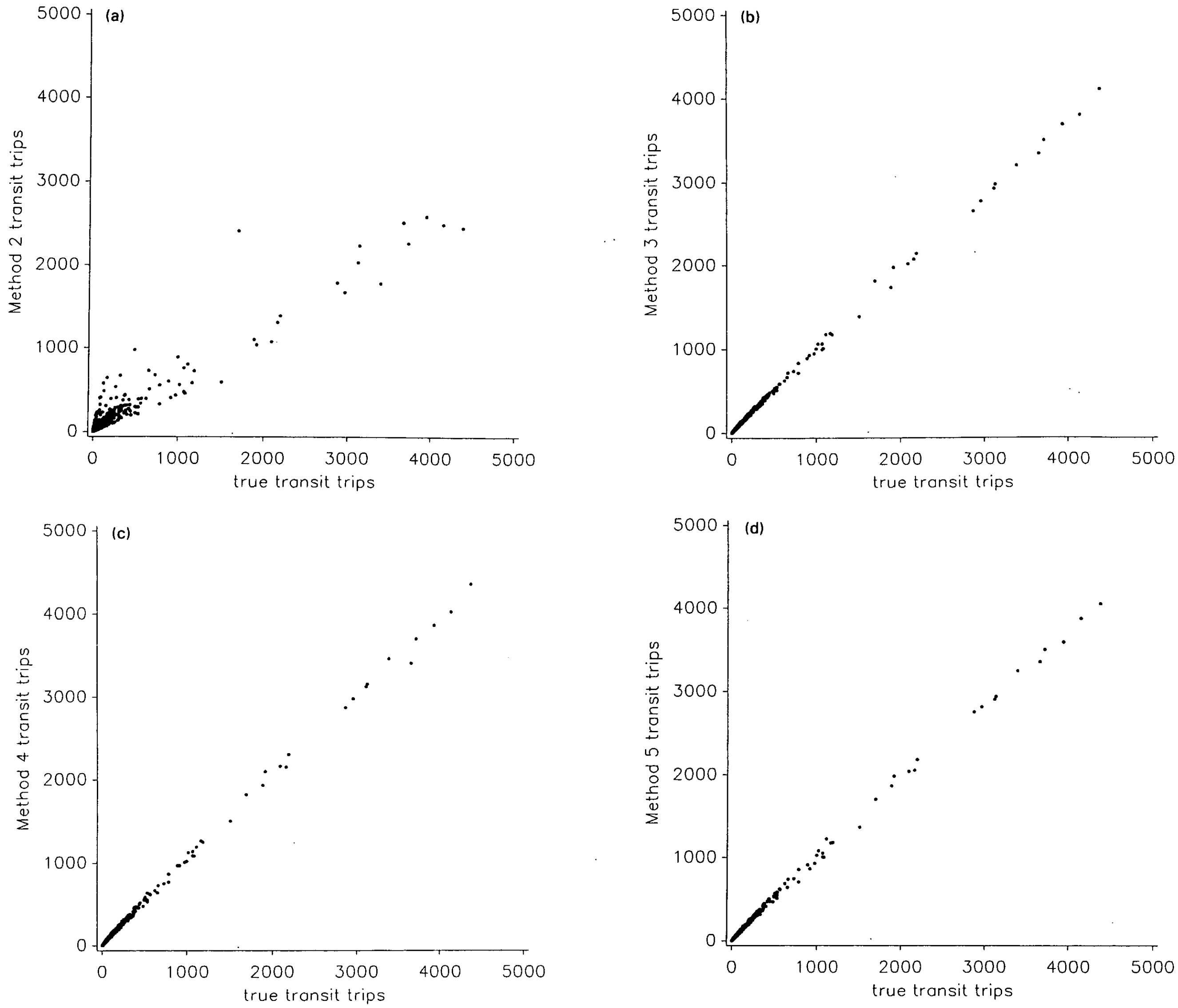

FIGURE 5 **Results for transit trips (Methods 2 to 5): (*a*) Method 2, (*b*) Method 3, (*c*) Method 4, and (*d*) Method 5.**

TABLE 4 Results of Five Methods for Automobile Costs

Method	Iteration	RMSE	Chi-sq	R-sq
1-5	1	.400	1877	.99
2	5	.664	5444	.97
3	5	.167	312	.99
4	1×5	.194	456	.99
5	5	.141	238	.99
3	10	.031	13	.99
4	2×5	.143	230	.99
5	10	.080	80	.99
3	15	.026	8	.99
4	3×5	.103	120	.99
5	15	.047	28	.99
3	20	.014	3	.99
4	4×5	.083	76	.99
5	20	.018	4	.99

number of O-D pairs - 100,489

Rapid improvements in desktop computing speed and memory should continue to facilitate the use of more appropriate methods than in the past. As recently as 1987 the only computer available to us to solve our Chicago region model repeatedly was a Cray supercomputer. Now we are solving it routinely on a Sun SPARCstation 2 with 32 megabytes of memory in 3.1 min per iteration. We believe that UNIX workstations of this type will be the computing platform of choice for planning agencies in the near future.

We conclude the paper with several observations concerning the implementation and adoption of equilibrium travel forecasting models. First, one might ask, why has it taken so long for convergent algorithms such as Methods 3 and 5 to be adopted in professional practice? We believe there are two aspects to this question. The first is that planning agencies apply models that are substantially more detailed than our own combined model. In particular they disaggregate origin-destination (O-D) tables by trip purpose and mode choice by user classes. Although these impor-

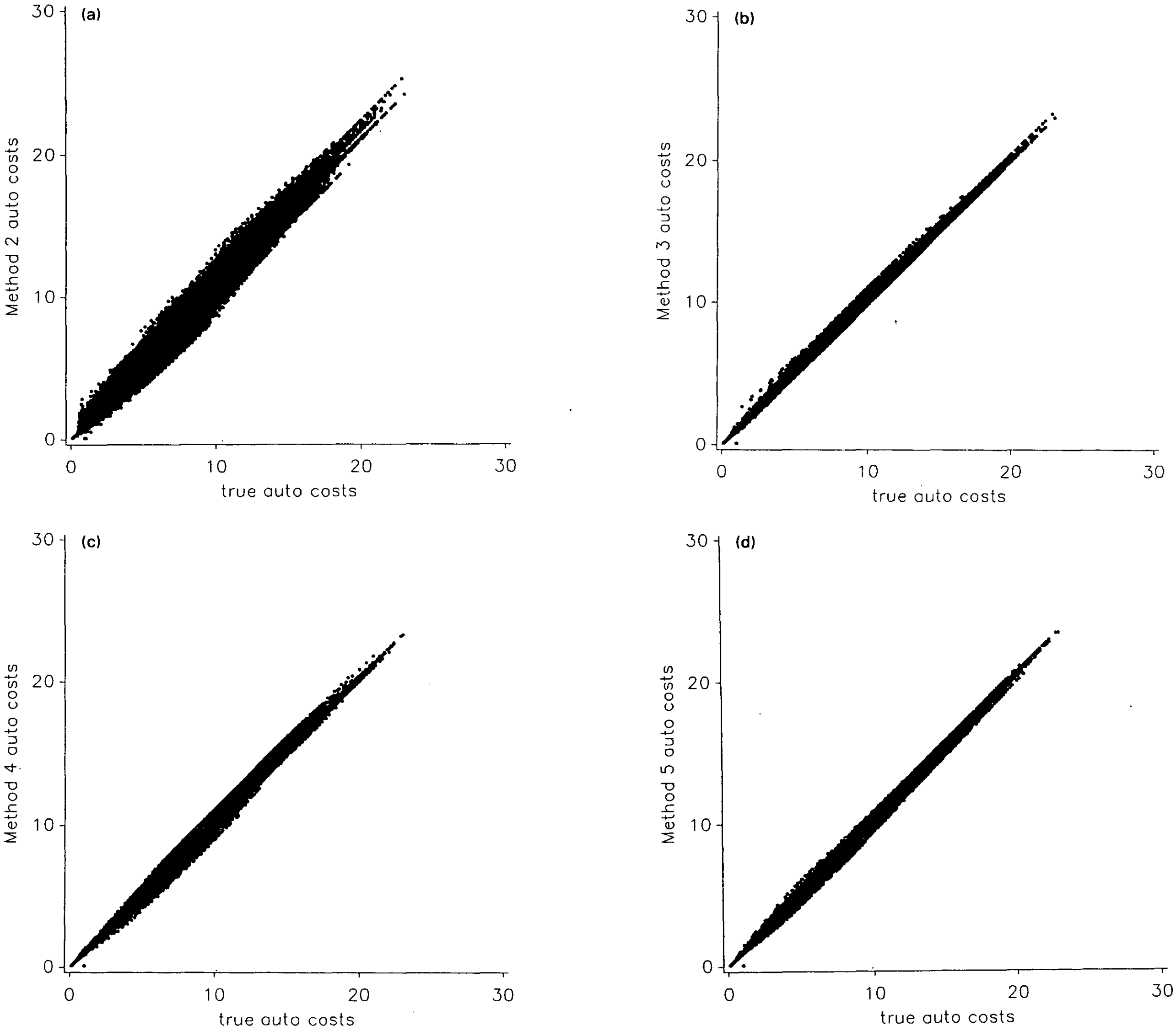

FIGURE 6 Results for automobile generalized costs (Methods 2 to 5): (*a*) Method 2, (*b*) Method 3, (*c*) Method 4, and (*d*) Method 5.

tant disaggregations ae not included in our present model, we are confident that it can be disaggregated in a similar manner. Moreover planning agencies have not faced much pressure to improve their methods until recently. In this situation they have continued to do what they knew from their own experience, which is the traditional four-step procedure.

The second aspect is that even if they had wished to adopt the new convergent methods the software was not available. "Why not?" one might reasonably ask, since some of the software developers are also leading researchers in transportation science. We asked this question on numerous occasions. The answer has been consistent: "software developers provide what the agencies demand."

We suggest that it is now time for metropolitan planning agencies, as well as FHWA and FTA, to demand software that yields the equilibrium solutions needed to meet the planning requirements of the 1990s. Let there be no further excuses on the part of practitioners *and* software developers for using obsolete methods.

Our next observation concerns the role of FHWA and FTA in training practitioners in their short courses. Is it not clear that the four-step procedure taught in these courses should be replaced by a modern approach? Again this will happen if the planning agencies demand it and not just accept at face value the recent statements about the need for "feedback." Surely they deserve better than this.

Finally those of us in the academic community need to assess our own shortcomings and responsibilities for this situation. We know of no book on travel forecasting methods that is accessible to professionals *and* describes a modern approach. Sheffi (*14*) has made a fine contribution to this subject, but his book is undoubtedly inaccessible to many practitioners and is now out of print. If we are to declare the four-step procedure obsolete there is no better place to begin than by writing new textbooks for both undergraduate and graduate courses. Such an effort will be substantial and would benefit from the financial support of FHWA and FTA under the Intermodal Surface Transportation Efficiency Act and the Clean Air Act Amendments.

TABLE 5 Selected Regional Attributes for Methods 2 to 5

Attribute	Solution Method				
iterations	2	3	4	5	true
Highway Vehicle Kilometers of Travel (kilometers x 10^6)					
5	17.19	13.56	13.17	13.43	13.23
10	14.06	13.39	13.44	13.30	
15	17.31	13.33	13.44	13.28	
20	14.07	13.30	13.41	13.27	
Mean Auto Travel Time (minutes)					
5	2037.9	27.6	26.7	26.9	26.3
10	4420.1	26.7	27.0	26.8	
15	1794.1	26.6	26.9	26.4	
20	4597.3	26.5	26.8	26.4	
Auto Space-Mean-Speed (kph)					
5	0.64	45.2	46.2	46.2	46.9
10	0.16	46.5	46.0	45.9	
15	0.64	46.5	46.2	46.7	
20	0.16	46.7	46.4	46.7	
Percent of Trips by Transit					
5	11.93	15.94	16.85	16.05	15.99
10	15.32	16.00	16.07	16.00	
15	12.02	16.20	16.01	15.97	
20	15.27	16.03	16.03	15.97	
Computational Effort (CPU seconds on Cray Y-MP)					
5	39.4	39.1	30.2	39.0	
10	51.8	70.3	51.5	69.5	
15	71.6	100.8	72.7	102.9	
20	136.2	131.4	94.1	132.4	

1 km = 0.6 mi.

This paper began with a reference to the last TRB meeting. At a workshop prior to that meeting the first author pleaded that we not forget what the research community has learned during the past 12 years that it spent in the wilderness since the demise of software development activities in FHWA and the Urban Mass Transit Administration [see also Weiner (*15*)]. During those years we have also experienced another computer revolution, if not two or three. It behooves us all—planning agency practitioners, software developers, federal program managers, and academics—to work together to ensure that the next generations of travel forecasting methods benefit rapidly from research findings, practical experience, and advances in computing technology.

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