Regularity Indices for Evaluating Transit Performance

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Service regularity measures for high-frequency transit are nonexistent at many transit operating agencies. Measures being used or those developed in theory are usually unsatisfactory for one of two reasons: (a) they do not control for the size of headways and therefore cannot be used to compare one route with another, or (b) they are not expressed on a normalized scale (i.e., bounded by 0 and 1). Two measures address these problems: the headway regularity index and passenger wait index. These indices are analyzed and compared both by means of mathematical analysis of data from simulations and by data from actual observation of bus routes in New York City.

This research originated with the Metropolitan Transportation Authority (MTA) inspector general's examination of the performance measurement systems used by the New York City Transit Authority (NYCTA). At the time this work was done, the NYCTA had no measure of the evenness of bus headways that was applied on a routine basis to all bus service. The NYCTA did calculate the percentage of excessive headways for bus routes when schedule revisions were made. By excessive headway, the NYCTA meant that the headway was more than 4 min greater than scheduled (*1*). This measure was used to demonstrate the effectiveness of the schedule revision program. The problem with this approach was that the 4-min standard had a different meaning when applied to service running every 2 min than it had for service running at 8- or 20-min intervals. Because the measure was used only for bus routes when schedule revisions were made, it was not being used to test whether other operational initiatives were successful.

The best previous regularity measure used by the NYCTA for subways was rush hour throughput—the percentage of trains scheduled that actually passed the observation point during a 1-hr interval. In practice, this measure became a measure of service volume and described little about the regularity of the intervals during the given hour.

A variety of measurement techniques are available to evaluate the performance of frequency transit services. These techniques include calculating the percentage of excessive headways (*1*), average wait (*2,3*), coefficient of variation for headways (*4*), and excess waiting time and standardized excess waiting time (*5*). All these techniques are useful analytical tools, but they have two major drawbacks.

Some of the measures depend on the average scheduled headway, that is, they have larger values for routes with larger headways. Therefore, a comparison of routes with different scheduled headways is not useful. Other measures are mathematically independent of the average headway (e.g., London Transit's standardized excess wait), or they at least control for headway variation (e.g., the headway coefficient of variation). These indicators allow comparison of routes, but their mathematical expression makes them difficult to evaluate. They are not represented on a normalized scale, so there is no set upper bound. Such measures are especially difficult for consumers to interpret, because it is difficult to tell how far the service diverges from the optimum. For example, the headway coefficient of variation is generally between 0 and 1 for bus routes, but at times it can exceed 1.

Two measures are examined for evaluating transit services—the headway regularity index (R) and the passenger wait index (W). Both indices control for the average headway and both are expressed on a normalized scale from 0 to 1.0. For perfect regularity, when all headways are equal, both measures equal 1.0. When all buses arrive bunched together, the value of both indices is 0. To simplify application of Gini's ratio to transit services, the headway regularity index is defined as one minus Gini's ratio (*6,7*). The passenger wait index is the ratio of the actual average wait to the minimum average wait (which occurs for perfect regularity).

These measures were examined by means of Monte Carlo simulations and other mathematical analysis. Headway data were generated randomly under a series of conditions to test how different configurations of headways produced different values for the indices and to show how these values compared with each other and with the coefficient of variation. In addition, the properties of the indicators were analyzed by examining their instantaneous rates of change.

The indices were explored also by applying them to empirical data from three case studies conducted by the inspector general's office for the MTA (*8–10*). The midday performances of the following selected New York City bus routes were examined: the Bronx Bx28, Bx30, Bx41, and Bx55; Brooklyn B35 and B46; and Manhattan M2, M3, M4, M7, M11, M16, Q32, M34, and M79. These routes were observed on randomly selected workdays between March and November 1989. The times of bus arrivals were recorded to the nearest half-minute.

HEADWAY REGULARITY INDEX

Gini's ratio is used by economists and sociologists to measure the degree of income inequality within groups of people (*6*). The task for transportation is somewhat different, but the technique is analogous. Inequalities in actual headways for bus routes are sought. To evaluate service quality and op-

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erational efficiency, the headway regularity index calculated for a given route can be compared with 1.0, the value of the index for perfectly regular service. Only actual headways are recommended for this analysis because adjusting the measure to compensate for scheduled unequal headways would put the results at odds with what passengers waiting at a particular location would experience.

The headway regularity index controls for the average actual headway. Just as the political economist can compare one nation's distribution of wealth with another's, without reference to which has the higher standard of living, headway regularity for the Bx41 bus route can be compared with that for the Bx30, though the two routes have quite different average headways.

Although a high value (near 1.0) for Gini's ratio indicates great income inequality, a high value (near 1.0) for R indicates regular service. A low value for R indicates irregular service and bus bunching.

Several properties of Gini's ratio mentioned in the *Encyclopedia of Statistical Science* (6) make the regularity index an attractive measure for evaluating transit performance.

1. Transfers. Supervisory actions, such as holding back buses or turning them short, if successful, will redistribute headways and increase the value of the index. This process is useful in testing the effectiveness of road supervision.

2. Scale Independence. Proportional addition or subtraction to all headways leaves the index unchanged. This means that schedule changes that increase or decrease the scheduled headway will not affect the index, except insofar as the changes improve or worsen service regularity. Scale independence also provides the justification for mathematical techniques for aggregating time periods with different scheduled headways, e.g., combining peak and off-peak service in a composite measure.

3. Normalization. The scale ranges from 0 to 1. All routes are calibrated to the same scale, making comparison possible. The upper limit provides a sense of how the given route compares with optimum service regularity.

4. Operationality. Because the index is straightforward, unambiguous, and objective, different researchers with potentially different subjective interests will still produce the same measure of regularity.

An illustration of the regularity index is shown in Figure 1. The horizontal axis is the cumulative proportion of buses (headways), ordered from the smallest to the largest headway. The vertical axis represents the cumulative proportion of the total headway minutes of the individual buses as they are arrayed on the x-axis. Expressing these axes as proportions, instead of the number of minutes or the count of buses, controls for headway size.

The diagonal line is the function that describes perfectly regular service, i.e., each bus adds an equal percentage of headway minutes to the total headway. The curve below that, known as the Lorenz curve (*11,12*), is the function that describes actual service. The black area represents the difference between actual service and perfectly regular service. The regularity index is the ratio of the shaded area to the area of the entire triangle. Gini's ratio is the ratio of the black area to the entire triangle.

In this diagram, the curve describing actual headway regularity indicates that the smallest 20 percent of the headways (buses) account for less than 5 percent of the total headway. The first 60 percent of the buses, ranked from the smallest to largest headway, accounts for about 40 percent of the total headway. The R value for the data used to make this diagram is 0.70. (The shaded area equals 70 percent of the triangle.)

The classical formula for Gini's ratio (*4*) is given in terms of an integral:

$$g = 1 - 2 \int LdF \tag{1}$$

The formula for the regularity index is

$$R = 2 \int LdF = 1 - g \tag{2}$$

where $\int LdF$ indicates the area under the curve for the actual observations, measured by calculating the definite integral. In the formula, L represents the function (Lorenz curve) that

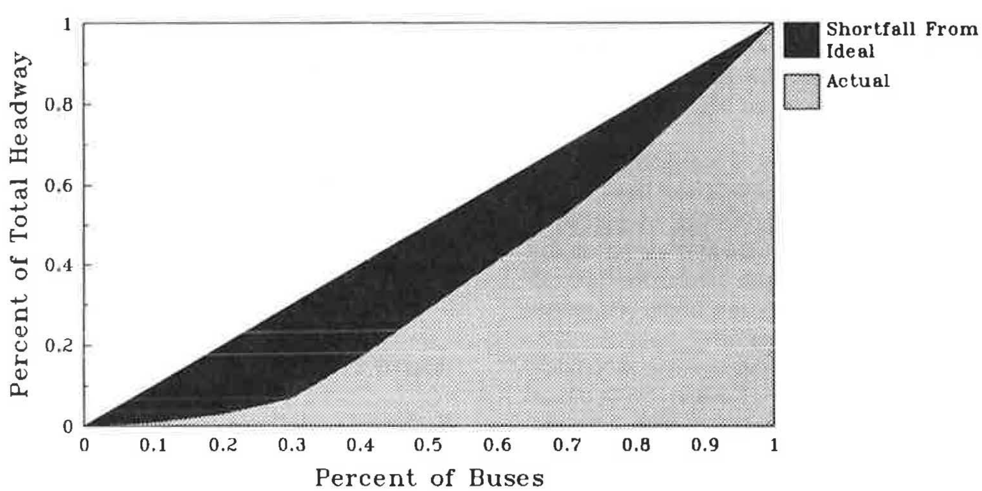

FIGURE 1 Calculation method for the regularity index. (Source: N.Y. State Office of the Inspector General for the MTA.)

describes the observed headways, and F represents the cumulative distribution function for the buses (ordered from smallest to largest headway), i.e., the x-axis in Figure 1.

However, the integral representation is not useful for calculating the measure with real data sets. Therefore, the following shortcut formula for R was developed:

$$R = 1 - \frac{2 \sum (h_r - H)r}{n^2 H} \tag{3}$$

where

h_r = series of headways;
r = 1, . . . n, the rank of the headways from smallest to largest; and
H = mean headway.

This formula is useful for calculating the regularity index on a standard spreadsheet computer program. In fact, attempts to array the data on the spreadsheet to calculate the index led to the discovery of the formula.

PASSENGER WAIT INDEX

The waiting time measures are applicable only to frequent service when it is assumed that passengers go to the stop without expectations of boarding a particular bus at a particular time (i.e., that passenger arrivals are Poisson distributed). When passengers are oriented to a scheduled time, different calculation methods are needed. At headways of 10 min or more, regularity measures are probably less desirable than on-time performance measures, as reflected in the measurement practices of London Transport (*13*).

The passenger's wait is a function both of the scheduled headway and of the regularity of service. The average wait increases as service regularity decreases. This may not be obvious. If 10 buses arrive in 1 hr, the average headway is 6 min no matter how regularly their arrivals are spaced. However, waiting times take into consideration the fact that passengers continually arrive at a bus stop and that more are affected by longer than by shorter headways.

The formula for average waiting time commonly used in transportation analysis were developed by Welding (*3*) in 1957 and further elaborated by Holroyd and Scraggs (*2*) in 1966. The formula Welding gave for average waiting time $E(w)$ is

$$E(w) = \frac{\sum h_i^2}{2 \sum h_i} \tag{4}$$

where h_i is the set of observed headways (the time between buses). The proper application of this formula assumes that (a) passengers arrive randomly at the stop (as represented by a Poisson distribution), and (b) they can board the first vehicle that arrives.

An alternative formula, showing that the average wait is a function of the coefficient of variation, is given by Bowman and Turnquist (*4*):

$$E(w) = \frac{H}{2}(1 + C_v^2) \tag{5}$$

where H is the mean observed headway and C_v is the coefficient of variation—the standard deviation of headways divided by the mean headway (H). Therefore, C_v^2 is the variance of headways divided by H^2.

For example, for 10 buses scheduled in a 60-min period, the average headway is 6 min and the minimum average wait (under conditions of perfectly even service) is 3 min. However, if actual service is less than perfect, the actual average wait exceeds the minimum average wait. In Table 1, 20 different combinations are presented for sets of 10 headways covering 1 hr. Case 6 has an average wait of 7.8 min, calculated using Equation 5. The more evenly distributed Case 17 has an average wait of 3.35 min.

The average wait, though an extremely important measure for evaluating service, depends on the average scheduled headway; therefore, it is unsatisfactory for comparing routes. Planners at London Transit devised a measure that they called "standardized excess wait," which is mathematically independent of the scheduled headway (*5*).

The formula for standardized excess waiting time is

$$S = \frac{n - 1}{2nC} (\text{var } h_i) \tag{6}$$

where n is still the number of headways, and C is some constant, equal to the scheduled headway of the service, or the mean observed headway at a chosen base point on the route.

TABLE 1 TWENTY SETS OF HEADWAYS FROM MONTE CARLO SIMULATIONS

	Headway Rank										Measures		
Case	1	2	3	4	5	6	7	8	9	10	R	W	C_v
1.	0	1	1	2	2	2	3	4	10	35	0.34	0.26	1.67
2.	0	0	0	2	3	4	4	6	8	33	0.35	0.29	1.56
3.	0	0	0	2	2	2	7	8	9	30	0.35	0.33	1.44
4.	0	0	1	2	2	2	4	5	16	28	0.35	0.33	1.43
5.	0	1	2	3	4	4	5	5	5	31	0.45	0.33	1.42
6.	1	1	2	3	4	4	5	5	7	28	0.49	0.39	1.26
7.	0	1	1	1	4	6	7	9	13	18	0.49	0.53	0.94
8.	1	1	1	1	5	5	7	7	9	23	0.50	0.47	1.06
9.	0	1	1	3	4	4	7	9	13	18	0.50	0.54	0.92
10.	2	2	2	2	3	4	5	6	7	27	0.52	0.41	1.20
11.	1	2	3	3	4	6	7	8	8	18	0.61	0.63	0.77
12.	0	1	4	5	5	5	5	8	11	16	0.61	0.65	0.74
13.	0	1	2	4	5	7	8	9	12	12	0.61	0.68	0.68
14.	0	2	5	6	6	6	8	8	9	10	0.73	0.81	0.49
15.	1	2	4	5	6	7	8	8	9	10	0.73	0.82	0.47
16.	2	3	3	7	7	7	7	8	8	8	0.81	0.88	0.37
17.	3	4	4	5	5	6	7	8	9	9	0.81	0.90	0.34
18.	2	3	5	6	6	7	7	7	8	9	0.81	0.90	0.34
19.	5	5	5	6	6	6	6	7	7	7	0.93	0.98	0.13
20.	5	5	6	6	6	6	6	6	7	7	0.95	0.99	0.11

Source: New York State Office of the Inspector General for the MTA (Service Review Unit)

However, this measure returns to the problem of interpretation for the coefficient of variation. Although a value of 0 (indicating no headway variance) is clearly the optimum service, S has no upper bound and the measure is not expressed in minutes or any other concrete unit of measurement. Also, the measure is intuitively difficult for the nonspecialist to grasp because increasing values indicate declining service, creating difficulties in explaining results to public officials or even senior management. Moreover, the method of determining the constant C is not clearly prescribed, so different researchers might have different results. London planners do not use this measure for public reports; their reports use average wait and average excess wait, both expressed in minutes.

The passenger wait index addresses both problems of previous measures. It controls for the magnitude of the scheduled headway, and it is expressed on a scale from 0 to 1. This index is calculated as the minimum average wait divided by the actual average wait. Expressed in terms of the formula given by Bowman and Turnquist (*4*),

$$W = \frac{1}{1 + C_v^2} \tag{7}$$

Calculating W also identifies the proportion of the average wait that is greater than the minimum average wait. For example, if W equals 0.60, then the minimum average wait is 60 percent of the actual average wait. Taking the reciprocal ($1/W$) indicates that the actual average wait is 10/6 of the minimum wait. On average, passengers waited 67 percent longer than desirable.

HEADWAY REGULARITY AND PASSENGER WAIT INDICES IN PRACTICE

Figure 2 shows the regularity index and the passenger wait index for each route studied. The 15 routes are arrayed from least to most regular. All routes except the Bx55 were scheduled at nearly even intervals where the observations were made. The lowest scores were for the B46, M7, and B35 bus routes. The highest score was for the Bx30 route. After the schedule of the Bx30 was revised by the NYCTA, the R value reached 0.90 and the W value became 0.95. Before the schedule change, for the Bx30 the R value was 0.82 and the W value was 0.87, still higher than for any other route measured. That these measures captured the improved regularity demonstrates their relevance for evaluating operational and planning actions.

The low level of service for many of these routes is the result of many factors. The NYCTA schedules, route configurations, and supervisory practices must be considered as contributing factors. But other key causes of irregular bus service are external to agency operations; they are consequences of the social, economic, and political features of urban life. Measures of bus service quality therefore go beyond the responsibility of transit providers and reach to broader political issues and the decisions made collectively regarding the role of public transit.

Regularity measures offer a way to assess the inconvenience experienced by transit riders from all causes and provide a way to measure progress in improving transit service by means of broader environmental, planning, and development policies. The effectiveness of the NYCTA's operating and scheduling changes can be assessed with these measures and reported publicly. Assessment of the traffic control and parking enforcement policies of local urban transportation agencies on public transit service quality is also made possible. One measure for internal and external factors helps facilitate a unified effort.

In general, the measures are in agreement regarding the quality of service. The differences in values are explained in the next section. The implications for choosing one regularity measure over another are discussed in the conclusion.

INTERPRETING VALUES OF THE INDICES

In order to understand the headway regularity and passenger wait indices more fully, a number of sets of randomly generated headways were studied. Table 1 presents 20 of the

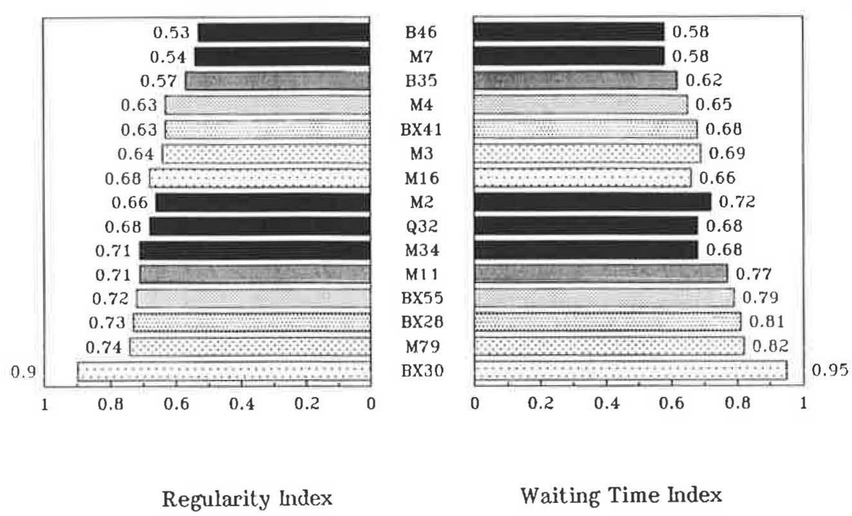

FIGURE 2 Midday performance for selected New York City bus routes. (Source: N.Y. State Office of the Inspector General for the MTA.)

thousands of cases generated, chosen to illustrate the behavior of the measures at different service levels. These cases are ordered from least to most regular, according to the regularity index. The headways are ranked from smallest to largest. The 10 headways in each set sum to 60 min. Cases 1 to 5 portray a level of service that is poorer than any bus routes yet observed. The headway pattern combines several bunched buses with one or more extremely large headways. The R values are 0.34 to 0.45, whereas the W values never exceed 0.33. The variance of the headways is large. This level of service is obviously not acceptable; both measures reflect this.

The service patterns in Cases 6 to 10 are similar to some patterns measured in practice that represent poor-quality service. When R is around 0.50, W can be either greater or less than R. Although it is not shown in Table 1, if W is held constant at 0.50 (when C_v is 1.0), R remains stable, varying only from 0.47 to 0.52. When $W < 0.50$, however, the R values can fluctuate considerably. For five cases (Cases 1 to 5) with $W = 0.33$, the R values ranged from 0.34 to 0.45. Outlying values—as in Cases 5 and 10—can have a large effect on the headway variance, and, consequently, on the wait index.

In Cases 11 to 13, the wait index begins to exceed the regularity index. In Cases 14 to 18, W exceeds R by a consistent amount, with the gap narrowing as both converge to 1.0 in Cases 19 and 20. The headway patterns grow consistently and obviously better, with C_v gradually tapering off toward 0.

In the cases presented in Table 1, $W < R$ when $R < 0.40$, and $W > R$ when $R > 0.60$. This pattern reflects the conditions of the simulation program more than mathematical inevitability. After many simulations, some of which were more consciously modeled as bus service, it became clear that W and R were typically about equal in the range below 0.45, after which W increased slightly more rapidly than R up to 0.90, when it tended to taper off. In all simulations, W exceeded R in the upper range of the scale, often as early as 0.60. In all simulations, the rate of increase for W began to decline after 0.90.

Figure 3 shows the differences in the rate of increase of the two measures. Beginning with Case 4 in Table 1 ($R = 0.35$, $W = 0.33$), 1 min was repeatedly transferred from the highest to the lowest headway until perfect regularity was achieved. One-minute transfers were used to analyze the behavior of the measure. This kind of micromanagement occurs in practice when dispatchers hold one of two bunched buses to redistribute the headway interval. Greater effect on the measure occurs when one bunched bus is used to split a large headway gap, also a common strategy of dispatchers.

The two measures were equal at 0.74, after which W is always greater (until both reached 1.0). The average rate of increase for R is constant, although it fluctuates from one step to the next and declines slightly for higher values of R. The rate of increase for W starts out lower than that for R, but it is an increasing function until 0.90, when it begins to decline.

The cause of this pattern is revealed by examination of the respective rates of change. For a set of headways (h_i with rank r_i, so that $i = 1, \ldots, n$), with values $x_1, x_2, x_3, \ldots, x_n$ and mean headway H, a transfer of d minutes from h_n to h_1 (i.e., from largest to smallest headway) will improve R by the following amount:

$$\Delta R = \frac{2d(r_n - r_1)}{n^2 H} \simeq \frac{2d}{nH} \qquad \text{when } n \text{ is large} \tag{8}$$

For the maximum change in R, $r_n - r_1 = n - 1$, the difference between ranks of the highest and lowest headways. The smallest change in R would be obtained by redistributing time between consecutive headways, so the difference in rank would be 1. For example, a redistribution from the largest to the next largest headway (see Cases 1 and 4 in Table 1) would make a smaller change. In this case, the numerator would include $r_n - r_{n-1}$, which is the same as $n - (n - 1) = 1$. Therefore, for the case of minimum change:

$$\Delta R = \frac{2d}{n^2 H} \tag{9}$$

Differences in rank are not independent of the actual headway values, because higher levels of regularity are marked by many even headways. For example, in Table 1, a transfer of 1 min for Case 19 from highest to lowest would be from r_8 to r_3, a difference in rank of 5. Such a transfer for Case 5 would give 9 as the difference in rank ($r_{10} - r_1 = 9$). Therefore, as

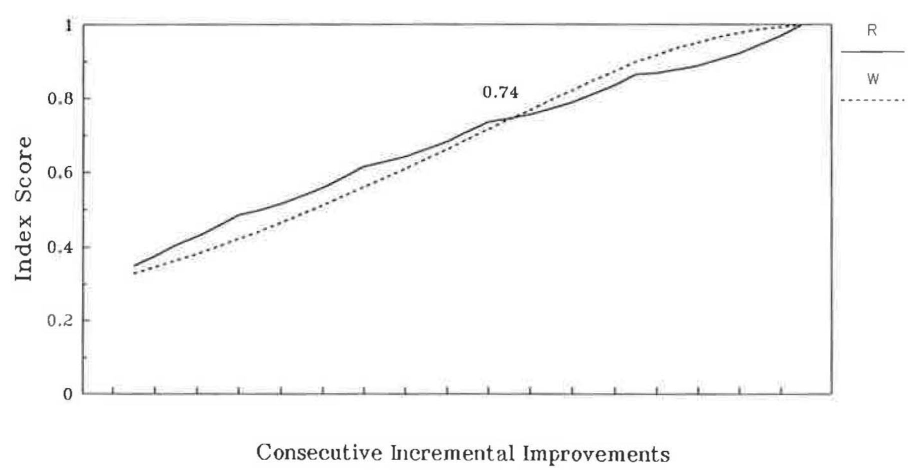

FIGURE 3 Improving regularity by 1-min increments. (Source: N.Y. State Office of the Inspector General for the MTA.)

R increases, the difference in rank between the headways involved in a transfer tends to narrow. The average rate of change at R therefore declines slightly as R improves.

The rate of change of W is less constant. Equation 10 yields the rate of change of the reciprocal of W, signified here as $1/W$. As the value of $1/W$ increases with better service [i.e., the difference between the largest (x_n) and smallest (x_1) headways gets smaller], the change in $1/W$ decreases. Because the numerator of the equation is always negative, a decrease in ($x_n - x_1$) causes the numerator to get larger (i.e., less negative).

$$\Delta(1/W) = \frac{2d[d - (x_n - x_1)]}{nH^2} \tag{10}$$

The formula for the rate of change of W is the following:

$$\Delta W = \frac{\Delta(1/W)}{[1 + C_v^2 + \Delta(1/W)]\,(1 + C_v^2)} \tag{11}$$

Figure 4 shows the rate of change for the wait index (W), for its reciprocal ($1/W$), and for the regularity index (R). A rolling average is used to iron out small fluctuations. The rate of change for $1/W$ is a nonlinear, constantly decreasing function, asymptotic to the x-axis. In the beginning, W increases about 0.017 with every minute transferred. W improves at a growing rate—depending on the value of C_v—to a maximum point; then its rate of increase declines. Between 0.70 and 0.90, the rate of increase peaks at 0.027 for every minute transferred. The value drops to 0.010 when W exceeds 0.97. The square of C_v in Equation 11 makes the rate of change for W a parabolic function.

CONCLUSIONS

Two measures of service regularity are presented here, the headway regularity index (R) and the passenger wait index (W). They are suggested as desirable measures of performance because they satisfy two conditions. First, they control for the mean headway, so they allow routes with different characteristics to be compared. (They are not independent of the mean headway in the strict mathematical sense.) Second, they are expressed on a normalized scale from 0 to 1.

Perhaps the most striking conclusion from comparative analysis of the two indices is the overall similarity of the results despite different calculation methods. Nevertheless, differences in behavior occur both for the values of the measures and for the rates of change. W is usually greater than R in the ranges of values corresponding to the bus routes studied, and W reaches values over 0.90 more quickly than R. When R is between 0.45 and 0.55, W provides more information than R about service levels. With W, Cases 6–10 in Table 1 can be distinguished, whereas with R they are lumped together. In a system where service is erratic, W may be more sensitive to improvement efforts.

However, once W reaches 0.90, it becomes more difficult to improve the rating. R, on the other hand, is slow to reach 0.90, but incremental improvements in regularity increase at nearly a constant rate. In Cases 19 and 20, a 1-min transfer from one headway to another increased R two points. R may be more appropriate for systems with good performance or situations for which it is possible to fine-tune the operations. W may be more adaptable to measuring change at lower levels of performance.

The different behaviors of the two measures reflect the fact that each measure emphasizes different aspects of service. They differ primarily in that the wait index is a function of the headway variance. All the waiting time indicators, including average waiting time, average headway, and the wait index, are more sensitive to outlying values and exhibit more nonlinearity than the regularity index.

The difference in emphasis corresponds to the distinction between an operational view and the passengers' view. For passengers, the extremely large headway should figure prominently in any account of performance. For operations managers, the size of the deviation is only part of the problem; the number of buses deviating must also be considered because it indicates the number of managerial interventions required to restore regular service.

Another practical consideration affects the decision regarding which index to choose. Because the wait index as-

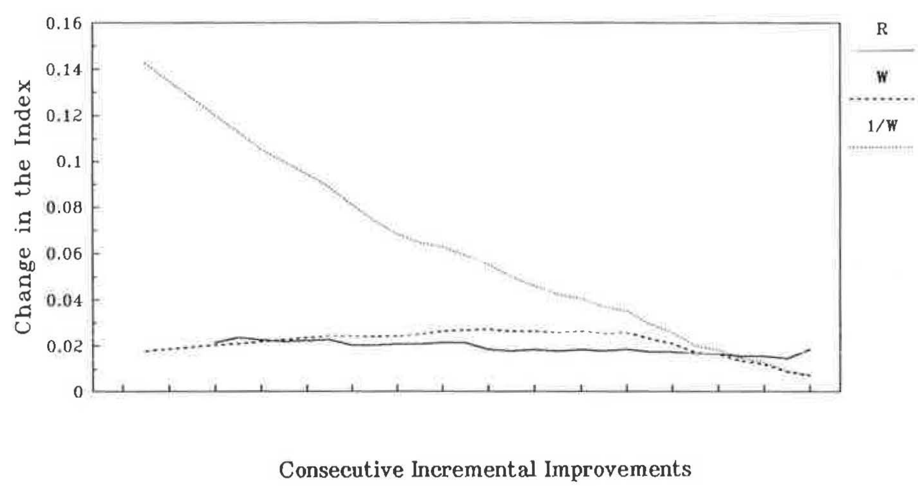

FIGURE 4 Changes in the regularity index. (Source: N.Y. State Office of the Inspector General for the MTA.)

sumes that the arrival pattern of passengers is Poisson distributed, it is inappropriate for infrequent transit services, when passengers can be assumed to know the schedule. Furthermore, its application becomes problematic when crowding is severe enough to violate the second assumption, that passengers can board the first vehicle that arrives. The regularity index is not hindered by these caveats because it refers exclusively to the headway distribution and ignores passenger arrival patterns.

A psychological dimension must be included in the evaluation of these indicators. The sensitivity of the wait index to extreme headways takes into consideration the riders' psychology. Although pertinent research is lacking, it seems plausible to assume, and it is consistent with personal experience, that after a long wait at a bus stop, each additional minute increases dissatisfaction with service disproportionately. Each additional minute's wait is increasingly frustrating and more conducive to anxiety about getting to one's destination or about whether the bus will ever come. Therefore, in Table 1, the wait index correctly rates Cases 6 and 10 worse than Cases 7 and 9. Similarly, it is appropriate that the rate of improvement in W should decrease after 0.90. At that level of regularity (see Cases 19 and 20 in Table 1), the improvement from a transfer of 1 min becomes difficult for passengers to discern, and small irregularities are less important.

On the other hand, a strictly operational measure should avoid such psychological arguments. The headway regularity index is more straightforward in this respect. Because its rate of change is more constant, it is preferable when used as a variable in multivariate analysis. Furthermore, the property of R of scale independence allows use of techniques for aggregating service at different time periods into a single composite measure. Aggregation with W may be more problematic. Finally, R is the only measure that can be used when it is known that passengers cannot board the first bus, unless other analytical techniques make it possible to calculate average wait under these conditions.

The values of the indices differed when applied to actual service. The value of W exceeded that of R for almost all routes. For many of the routes, however, both indices were low, signifying poor performance. For example, for the B46 route, both the R value of 0.53 and the W value of 0.58 clearly represented low-quality service as well as inefficient operation.

The issue of what score indicates a good level of service is more complex. Experience with a large body of empirical data would make the evaluation of service with these measures more meaningful. Once this type of data is acquired for a wide range of bus routes over time, analysts can group routes according to operating and environmental characteristics, and make comparisons between one route and another or between a given route last year and its performance this year. Such empirical data for route performance would also make it possible to set goals for individual routes that would serve as a basis for the evaluation of specific policies and managerial actions.

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