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PERFORMANCE INDICATORS FOR TRANSIT MANAGEMENT*

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ABSTRACT

Transit performance can be evaluated through quantitative indicators. As the provision of efficient and effective transit service are appropriate goals to be encouraged by federal and state governments, these goals are used to develop performance indicators.

Three efficiency and four effectiveness indicators are described, together with two overall indicators. These nine indicators are analyzed for comparability utilizing operating and financial data collected from public transit agencies in California.

Performance indicators selected for this study should not be viewed as final. Twenty-one performance indicators proposed by previous studies were reviewed. Theoretical considerations and unavailability or unreliability of data caused omission of several useful measures like passenger-miles. Circumstances such as improved data, emphasis upon goals other than efficiency and effectiveness, and local conditions might warrant the inclusion of indicators deleted from this research.

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Priorities in transit over the past decade have changed from the use of capital assistance to emphasis on improved management and better utilization of existing facilities and resources. With these changes in conditions and priorities, there is increasing emphasis upon the evaluation of public transit performance.

Performance evaluation requires the establishment of clear goals for transit and the specification of indicators appropriate to those goals. For the federal and state levels of government, providing transit services <u>efficiently</u> and <u>effectively</u> are significant goals for transit. Efficiency indicators rate the processes by which transit services are produced, particularly through the relationship of inputs to outputs. Effectiveness indicators compare service actually provided to output or objectives which were intended: they examine the character and location of service. A useful way of clarifying these two terms is to say that efficiency is concerned with "doing things right," whereas effectiveness is concerned with "doing the right things."

PRIOR LITERATURE

The concept of transit performance evaluation and the development of performance indicators is not new. The National Committee on Urban Transportation (1958), in their comprehensive report, specified service standards, objectives, and measurement techniques for transit. This study originated many of the measures and standards used by transit today.

Tomazinis (1975) defines the conceptual and methodological aspects of evaluating productivity, efficiency, and quality of urban transportation systems, and insists that measures of efficiency in the use of resources be separated from measures of effectiveness (quality) in achieving ridership.

Allen and DiCesare (1976), discuss the need for evaluation of transit service and provide an overview of the theory of evaluation methodology. They conclude that transit service can indeed be measured and that the effort to develop a comprehensive evaluation scheme--while considerable--would be justified.

Gilbert and Dajani (1975), examine possible perspectives (federal, state, local, user, and operator) which an evaluation system might take and conclude that the interrelated nature of these perspectives necessitates a conceptual framework to assist in selecting appropriate performance indicators. Their conceptual framework emphasizes three levels of evaluation: efficiency, effectiveness, and impact.

The rationale for the development of performance indicators based upon efficiency and effectiveness is established by prior literature. This paper continues this research by analyzing potential indicators, assessing their usefulness to transit management and by applying selected indicators to data collected from transit properties in California. The computed indicator values are used to investigate the effects of service mode, organization type, service area characteristics on individual indicators, and on the comparability of indicator values. Previous studies had neither investigated as many transit systems, nor related performance indicators to managerial attributes.

INDICATORS OF EFFICIENCY

Efficiency indicators are used to evaluate the process by which transit services are produced; that is, the relationship of inputs to outputs. The first two of the proposed efficiency indicators have the advantage of being measured in physical units, rather than dollar units. This facilitates comparisons across properties, because these measures are relatively independent of differences in wages and prices among cities. Furthermore, since they both use vehicle hours rather than vehicle miles as their measure of output, they are also relatively independent of differences in speed, congestion, and trip length among cities.

Revenue Vehicle Hours Per Employee: an efficiency measure of labor productivity. This indicator will be affected by the size of the administrative staff of a property, its peak/off-peak ratio, hours of service, and labor work rules. The use of "total" employees in this measure introduces some error as workday and workweek lengths may differ significantly between properties and yet appear the same in this measure. Total employee hours would be a better denominator, but is not generally available.

Revenue Vehicle Hours Per Vehicle: an efficiency measure of vehicle utilization. This indicator is affected by the service hours of the property, the peak/off-peak ratio, labor work rules, and the daily service vehicle/total fleet ratio. Since vehicle costs are a much smaller portion of operating costs than labor, a favorable score on this indicator is not as important in transit management as a high score on the previous indicator.

Operating Expense Per Revenue Vehicle Hour: an efficiency measure of total inputs per unit of provided service. This indicator is affected by a property's peak/off-peak ratio, hours of daily service, and labor work rules. Properties which share support facilities with other organizations, e.g., a municipal operator whose maintenance and accounting is done by the larger municipal organization, may achieve somewhat inflated efficiencies on this indicator if costs of such services are not fully billed to the transit operation.

INDICATORS OF EFFECTIVENESS

Effectiveness is the comparison of produced output (provided service) to intended output or objectives; that is, "doing the right things." Measures of effectiveness are concerned with the extent to which the service provided--in terms of quantity, location, and character--corresponds to the goals and objectives established for it by government and to the needs of the citizens.

Accessibility of provided service to the area's residents may be evaluated using the indicator "Percent Population Served," which measures the proportion of the service area population within 1/4 mile of a regularly scheduled transit route. More comprehensive measures could be developed to consider, for example, special target populations and levels of service, but would require generation procedures and data which are not commonly available at the time of the research.

The "fit" of provided transit service to the needs and travel demands of an area is approximated by the number of passengers utilizing that service. The number of passengers served is a key indicator but there are measurement problems stemming from the methods used to do the counting. Although it would be relatively simple to do a headcount of all the people who board the transit vehicle, it is seldom done on a regular basis. Most properties rely upon periodic surveys and estimates based upon farebox revenues. This figure is reported as Total Passengers. It deviates from the ideal concept (the number of passengers traveling from origin to destination) because people who transfer between vehicles are counted again and again, every time they board another vehicle. Thus, in some cities, the Total Passenger statistic will be a great deal higher than is justified.

Estimating the number of passengers based upon the fares paid is more reliable: this figure is reported as Revenue Passengers. It deviates from the ideal measure because some cities have free fares and most have discount fares for certain classes of passengers such as senior citizens. Thus in some cities the Revenue Passenger statistic will considerably underestimate the number of actual trips.

Since the desired concept, the total number of "linked" trips, from origin to destination, is not reported by all properties at present, both Total Passengers and Revenue Passengers are used in the indicators that follow: one overstates the effectiveness of the transit system and the other understates it. A few properties do report "linked" trips, and most will in the future as this statistic is required to be reported as an element of the Urban Mass Transportation Industry System of Uniform Accounts and Records and Reporting System (U.S. Department of Transportation, 1977). When available, statistics on "linked" trips should be utilized in effectiveness measures.

Revenue Passengers Per Service Area Population: an effectiveness measure of the penetration of transit into its potential market. Obviously, one important factor here is the definition of "service area"; a definition which is generally made by political agencies rather than by transit managers. To the extent that political agencies have a strong incentive to increase the size of the service area, this indicator may be unfair to some properties.

Percent of Population Served: the proportion of the service area population that has access to transit service. This indicator also has a potential problem with the political definition of the service area. Another weakness is that it only measures whether someone is near (within 1/4 mile of) transit service, not how good that service is: for example, it ignores both frequency of service, and circuity of routes. Demand-responsive systems will have scores of 1.00 because access is uniformly available throughout the service area.

Total Passengers Per Vehicle: an effectiveness measure of system patronage and capacity utilization indexed to an average transit vehicle. This indicator is affected by average trip length, rate of transfers in the system, peak/off-peak ratio, and daily-service-vehicle/total-fleet ratio.

Revenue Passengers Per Revenue Vehicle Hour: an effectiveness measure of system patronage per unit of produced service. This indicator is affected by the peak/off-peak ratio, hours of service, vehicle capacity and average trip length of a property.

OVERALL INDICATORS

The remaining indicators are overall performance measures for a transit system: they combine some aspect of efficiency with some aspect of effectiveness in a single indicator.

Operating Expenses Per Total Passenger: an indicator of total resource inputs per trip. A system with an unusually high rate of transfers would look artificially good on this measure since it is based on total, "unlinked" trips; and hence is using too large a divisor. A further problem is that it ignores operating revenues. A system that charged extremely low fares, thereby attracting more passengers, would look very good on this measure even though its operating ratio was very poor.

Operating Expense Per Revenue Passenger: an indicator of total resource inputs per trip. A system with an unusually high number of free-fare passengers would look artificially bad under this measure, because the divisor would be understated. A further problem is that it ignores the fare effects mentioned above.

SELECTION OF PERFORMANCE INDICATORS

The performance indicators selected and applied in this study should not be viewed as "final". Circumstances such as improved available data, emphasis on goals other than efficiency and effectiveness, and local conditions might require inclusion of indicators deleted here or the development of new measures of transit performance.

The selection of indicators for this study was influenced by the information available in California and in the Seattle-Tacoma metropolitan area and by the accuracy of that information. Choice of the indicator set represents a judgment about the theoretical validity of the individual measures, about their appropriateness in transit management, and their availability (Fielding, Glauthier, and Lave, 1977, pp. 9-13).

Desirable, But Presently Unavailable Indicators: The evaluation of available financial and operating information has resulted in the finding that very few data elements are widely available from transit operators. Many potentially valuable statistics are not collected or computed on a regular basis; among these are passenger miles and employee hours.

Passenger miles and seat miles are much more accurate measures of service consumed and service produced than total passengers carried or total vehicle miles. Passenger miles provides an indication of average vehicle occupancy and trip length and is therefore highly significant to understanding vehicle utilization and service consumption. However, passenger miles were not generally available at the time the data was collected, although they will be available in the future as the UMTA reporting requirements are implemented.

Seat miles provides a measure of the total produced service which takes into account seating capacity of the transit vehicle. Because it is vehicle miles multiplied by seating capacity, the seat miles statistics holds potential for comparing systems utilizing different capacity vehicles. Seat miles, however, do overlook the standee capacity of the vehicle which is important in metropolitan areas where a significant portion of system utilization occurs at peak periods.

Statistics on employee hours would constitute a much more accurate measure of labor input than total employees, which is normally all that is available. Employee totals give no information as to length of shifts, overtime hours, or part-time workers.

The nonavailability of these data elements necessitated the deletion of indicators requiring them. These indicators were: Operating Cost Per Seat Mile, and Operating Expense Per Passenger Mile (Fig. 1).

Amenability of Indicators to Short-Term Change: Particular performance indicators, because of the factors they evaluate, may not be amenable to change over relatively short time periods. Energy efficiency measures are among such indicators. The energy efficiency of a property is primarily a function of the vehicles it operates. The purchase of these vehicles, in turn, is the result of decisions made over a period of years. During a single year, little change may be expected in energy efficiency scores, thereby making indicators of energy efficiency of little value as measures of transit performance.

Fig. 1: Examined Performance Indicators

Indicator	As Measures of:
EFFICIENCY:	
Revenue Vehicle Miles Per Employee Total Vehicle Miles Per Employee Revenue Vehicle Hours Per Employee	Labor Productivity
Revenue Vehicle Miles Per Vehicle Total Vehicle Miles Per Vehicle Revenue Vehicle Hours Per Vehicle	Vehicle Utilization
Operating Expense Per Seat Mile Operating Expense Per Revenue Vehicle Mile Operating Expense Per Total Vehicle Mile Operating Expense Per Revenue Vehicle Hour	Expense Per Produced Output Unit
Energy Consumption Per Revenue Vehicle Mile Energy Consumption Per Total Vehicle Mile Energy Consumption Per Revenue Vehicle Hour	Energy Efficiency
EFFECTIVENESS:	
Percent Population Served	Accessibility
Revenue Passengers Per Service Area Population Total Passengers Per Vehicle Revenue Passengers Per Revenue Vehicle Mile Revenue Passengers Per Revenue Vehicle Hour	Utilization of Service
OVERALL:	
Operating Expense Per Total Passenger Operating Expense Per Revenue Passenger Operating Expense Per Passenger Mile	Expense Per Consumed Output Unit

APPLYING THE INDICATORS

In order to test the selected performance indicators, annual operating and financial data were collected from forty-six public transit operators in California. These data were obtained primarily from public documents, supplemented and verified through interviews with representatives of each property.

Analysis of the operating and financial data of the selected California operators revealed that much less data were available than we had anticipated. Furthermore, a significant amount of the data which were available suffered from inconsistencies in definitions and data generation procedures. These problems impair the reliability of the reported indicator values. They also severely limited the usefulness of the results obtained from statistical analyses on the data set.

Table 1 shows the average values of the indicators for the California properties. The sample has been divided into demand-responsive systems,

		EFFICIENCY			EFFECTIVENESS				OVERALL	
	# OF CASES	REV VEH HRS PER EMPLOYEE	REV VEH HRS PER VEHICLE	OPER EXP / REV VEH HR	REV PAS / SVC AREA POP	% POP SERVD	TOT PAS / VEHICLE	REV PAS / REV VEH HOUR	OPER $ / TOT PAS	OPER $ / REV PAS
FIXED ROUTE	38	1,180	2,260	$ 17.70	17.9	.79	58,500	22.0	$ .87	$ .98
DEMAND RESP.	8	1,730	2,120	$ 10.30	1.6	1.00	11,100	5.0	$ 3.27	$ 3.47

TABLE 1: AVERAGE VALUES OF THE PERFORMANCE INDICATORS

and fixed-route-bus systems because of the fundamental differences in these two types of service.

The differences in indicator values between the two types of systems are all in the expected direction since demand-responsive systems tend to be smaller, in both size and vehicle capacity, and to use less expensive labor.

It is also possible to apply these indicators to individual properties, though this must be done with considerable care. The most reliable comparisons involve the performance of a particular system over time; that is, comparing this year's indicator values to some previous year's values for the same property.

Comparisons between properties are much more difficult. Some indicators are significantly influenced by political and geographical factors which are outside of the control of the transit managers. Hence, a direct comparison between two specific systems is subject to the "environmental" idiosyncrasies associated with both systems, and is generally inappropriate unless the systems are carefully matched to hold some of these exogenous factors constant.

Comparison of one system with the average indicator values of all systems presents fewer problems. The averaging process tends to even out fluctuations and produces a reasonable baseline. We then need worry about only one set of idiosyncrasies; those of the specific property which is being compared to the average value. For the comparison of one system against "par" performance, we need a good deal of knowledge about the character and geography of its service area, knowledge about its political and social constraints, and knowledge about its services and organization. Three examples of this type of analysis follow:

Case #1

Table 2 shows the indicator values for the first case: a new fixed-route transit district, which was created through the acquisition of two municipal systems. It serves a low density surburban area spread across several cities and some adjoining county territory.

	EFFICIENCY			EFFECTIVENESS				OVERALL	
	REV VEH HRS PER EMPLOYEE	REV VEH HRS PER VEHICLE	OPER EXP / REV VEH HR	REV PAS / SVC AREA POP	% POP SERVD	TOT PAS / VEHICLE	REV PAS / REV VEH HOURS	OPER $ / TOT PAS	OPER $ / REV PAS
SAMPLE PROPERTY # 1	1,080	2,500	$ 23.20	8.3	.75	60,700	20.8	$ .96	$ 1.11
AVERAGE FIXED-ROUTE PROPERTY	1,180	2,260	$ 17.70	17.9	.79	58,500	22.0	$ .87	$ .98

TABLE 2: CASE # 1. A NEW FIXED-ROUTE PROPERTY

Comparing the indicator values for this property to the average values for all of the fixed-route properties, this property rates unfavorably on two of the efficiency indicators, three of the effectiveness indicators, and both of the overall indicators. The unfavorable indices for cost-related measures and Revenue Vehicle Hours Per Employee are to be expected. As a newly created district, it can be expected to have higher costs and more employees than established systems because of the start-up costs and special demands (marketing, planning) connected with implementing service.

The two indicators based on service area population, Revenue Passengers Per Service Area Population and Percent Population Served, are also unfavorable--the first, appreciably, the second only slightly. These both are affected by the large size of the property's service area and the difficulty of developing ridership when population density is under 500 persons per square mile. Because of the extreme dispersion of population in this area, it is possible that patronage cannot be developed to the level achieved in other areas. This kind of comparison has two values: it identifies opportunities for improving performance and, when compared with the achievements of similar transit systems, it provides guidance for estimating future equipment needs, operating costs, and ridership.

Case #2

Table 3 shows the indicator values for the second case: a municipal demand-responsive system. In comparison to the average demand-responsive system, this property receives unfavorable scores on all three efficiency measures. But all four effectiveness scores are very good; in fact, so good that they produce favorable ratings in the two overall indicators as well.

	EFFICIENCY			EFFECTIVENESS				OVERALL	
	REV VEH HRS PER EMPLOYEE	REV VEH HRS PER VEHICLE	OPER EXP / REV VEH HR	REV PAS / SVC AREA POP	% POP SERVD	TOT PAS / VEHICLE	REV PAS / REV VEH HOUR	OPER $ / TOT PAS	OPER $ / REV PAS
SAMPLE PROPERTY # 2	633	1,480	$ 17.50	3.2	1.00	17,400	10.8	$ 1.49	$ 1.62
AVERAGE DEMAND-RESP. PROPERTY	1,730	2,120	$ 10.30	1.6	1.00	11,100	5.0	$ 3.27	$ 3.47

TABLE 3: CASE # 2. A DEMAND-RESPONSIVE PROPERTY

The unfavorable score on employee productivity, Revenue Vehicle Hours Per Employee, is due in part to a data error. The statistic was computed on a reported figure of 11 full-time drivers, which should actually be 3 full-time and 8 part-time. When employee productivity is recomputed, counting only 7 full-time-equivalent drivers, the indicator value is raised to 1270--still below average but much improved. This again reinforces the necessity of having clearly defined data.

The unfavorable efficiency indicators, as a whole, reflect the limited service hours provided by this property. These indicator scores could be improved through lengthening of service hours, possibly with commensurate increases in patronage. However, this decision must take into consideration local travel desires, and the willingness of local agencies to contribute the additional matching subsidy.

Case #3

The third case is a long established, fixed-route system operating in a high density service area of about 7,000 residents per square mile. The calculated indicator values are shown in Table 4.

	EFFICIENCY			EFFECTIVENESS				OVERALL	
	REV VEH HRS PER EMPLOYEE	REV VEH HRS PER VEHICLE	OPER EXP / REV VEH HR	REV PAS / SVC AREA POP	% POP SERVD	TOT PAS / VEHICLE	REV PAS / REV VEH HOUR	OPER $ / TOT PAS	OPER $ / REV PAS
SAMPLE PROPERTY # 3	1,180	2,340	$ 19.40	35.2	.97	91,400	36.2	$ .50	$ .54
AVERAGE FIXED-ROUTE PROPERTY	1,180	2,260	$ 17.70	17.9	.79	58,500	22.0	$ .87	$ .98

TABLE 4: CASE # 3. AN ESTABLISHED FIXED-ROUTE PROPERTY

Compared to the average fixed-route property, case number three scores well on vehicle utilization efficiency and average on employee productivity. It is about 10% above average cost on Operating Expense Per Revenue Vehicle Hour.

The property's highly favorable effectiveness scores reflect its well-established routes, high service area density, and the existence of a large segment of the population who are reliant upon transit.

The combination of a high rating on Revenue Passengers Per Revenue Vehicle Hour, plus the favorable efficiency ratings on vehicle productivity, suggests that there are few hours of unproductive service. Longer service hours might bring all scores above the mean, but there is no indication that any real benefit would be achieved through such action.

USING PERFORMANCE INDICATORS

The preceding cases have shown that an individual property's performance indicator values may be interpreted in a useful way, given some basic knowledge of that property's operations and character. However, it has also been demonstrated that incorrect or misinterpreted data can lead to misleading indicator values and possibly unfair conclusions.

Since, at the present time, there is a significant possibility of incorrect data, misinterpreted data, and even politically-manipulated data, we urge substantial caution in the calculation and interpretation of these indicators. Even greater caution is required in any comparative analysis based on these indicators. Nonetheless, there are a number of possible applications which seem quite attractive for management and for public policy use.

Management Uses of Performance Indicators: Performance indicators can assist management by identifying activities in which achieved indicator values are either above or below those of other, similar transit properties. Such activities would be candidates for examination to determine if anything is wrong or what in particular is being done especially well.

Management should select the indicators they feel are appropriate and the property or properties which are somewhat similar in operations, size, and local conditions. Comparison could be against public operating and financial data or against data obtained directly from the other properties. The comparison could also be against published "par" values for different types and sizes of transit operations.

The advantage of this form of internal management comparison is that historical performance and hard-to-quantify factors can be incorporated into the interpretation. This process provides a rationale for limiting the foci of management while maintaining a periodic monitoring of many aspects of performance. Finally, this technique could facilitate the initiation of discussion between similar properties to investigate differences in such activities as operating techniques, costs, and marketing.

<u>Evaluating Suborganization Performance</u>: Performance indicators may also be developed and applied to operating divisions and special departments of the transit organization such as maintenance or claims. The establishment of subsystem evaluation measures must follow the determination of goals and objectives for the organization as a whole and then for its separate elements. This process in general is termed "Management By Objective" or simply "MBO." MBO is a highly structured management tool in which organizational goals, objectives, and evaluation processes are clearly defined for each level of the organization from the entire system down to the work group or individual.

While the MBO process need not be adhered to precisely, it serves to require explanation of goals and clarification of priorities. It also makes known management's evaluative criteria, thus reducing some of the aura which typically surrounds management decisions in transit.

The determination of appropriate performance indicators for organizational sub-elements also facilitates the establishment of reasonable performance objectives. Such objectives would be designed so that their attainment would promote the goals of the overall organization.

Other related suborganizational uses for performance indicators would be in route evaluation and facilitating labor negotiations. As performance measures gain acceptance, management and labor could seek equitable ways in which such indicators might provide a non-controversial basis for negotiations.

Public Policy Uses of Performance Indicators: In a public organization such as transit, the overall philosophy of the organization, the service policies, and the operational guidelines are usually established by a political decision-making body. In the earlier discussion of Management By Objective, the political body would be responsible for setting forth the organization-level goals.

Many goals may be suggested for transit, yet not all may be pursued simultaneously. Performance indicators provide a means for evaluating the trade-offs between various goals in terms of services provided, the quality of those services, and costs.

Once goals are selected and priorities established, performance indicators may be selected and standards defined which evaluate the transit system's performance relative to those goals and its progress toward their attainment.

In developing uniform performance indicators based on commonly defined statistics, a "language" is created through which the effects of new programs and technology may be evaluated and findings disseminated. The use of common evaluation measures and descriptive statistics may increase the transferability of demonstration projects and management innovations.

Uniform indicators also permit comparison of evaluation results of similar demonstrations and improvements between different transit properties in different areas and at different times. One current example of how indicators might assist in evaluating program alternatives is in service to the handicapped. If alternate means of providing such services were evaluated on common measures, the various projects might be more easily compared in terms of cost and effectiveness.

The development and application of uniform performance indicators will provide transit with a more accurate and usable system of contemporary and historical records. Research into the effects of environmental and operational characteristics on performance indicators should continue so as to permit better control of these variables. The variables that management can control will then be isolated and valid performance comparisons for new programs between areas, and through time, will be possible.

CONTINUING THE RESEARCH

Many areas of transit performance and performance evaluation may be identified which require further investigation. One general category of needed research concerns the use and interpretation of indicators. Among research issues in this category are: the better understanding of the performance indicators used in this study; the application of indicators to transportation modes other than fixed-route and demand-responsive buses; the definition, collection, and generation of data; and the use of indicators of service quality.

Another category of research must focus on transit's environment. Specific issues are: the effects of geography and demography on transit; the effect of organizational structure; and the effect of economic and labor conditions on transit performance. A start in this direction has already been made. Production function analyses and multiple regression techniques have been used to analyze the determinants of overall effectiveness and efficiency, but the results were disappointing largely because of the unreliable data presently available on transit performance (Lave and Pozdena, 1977).

The performance indicator set and individual indicators presented in this paper are the first iteration of an evolutionary process. Better operational data will become available as a result of the Urban Mass Transportation System of Uniform Accounts and Records and Reporting System (1977). This new information may make certain measures desirable which are presently not included. Other, better measures may be developed to replace existing indicators. Different uses for the indicator set and different local requirements may necessitate heavier emphasis upon particular measures or inclusion of additional indicators. That is, we expect these indicators to evolve with use. We also expect that such experience will provide a much better understanding of how the indicators work, what they can and cannot do, and the kinds of applications they may usefully address.

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