URBAN PUBLIC TRANSPORT PERFORMANCE : SOME NEW ZEALAND FINDINGS PUT INTO CONTEXT

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ABSTRACT:

This paper is concerned with the measurement of performance of urban public transport services, with an emphasis on bus services. It discusses the purposes of performance measurement in urban public transport systems and the structuring, applications and limitations of performance indicator 'packages'.

The development of a system to assist the New Zealand Government in monitoring the performance of the four major municipal bus operators is described. Evidence is presented on trends in their performance over the last 10 years and on comparisons between them.

The paper also companies the New Zealand data with data for selected bus, tram and urban rail operations in China, to indicate the wide differences between performance characteristics in Australasia and in a developing country.

1. INTRODUCTION

There has been a growing concern and interest over the last few years in New Zealand, Australia and elsewhere about the efficiency and effectiveness of public transport. This has arisen from a range of interest groups, including politicians, public servants (particularly those in finance departments), unions and user groups. There are a number of reasons for this:

* Subsidies increased rapidly in real terms during the late-1970s and 1980s, in Australia, New Zealand and many other countries.
* Government funding generally is being restrained, due to economic circumstances and pressures towards 'smaller government'.
* In this climate, there has been increasing concern that a large proportion of subsidies are not going to those users for where they were intended, but are 'leaking' into reduced efficiency.
* A number of government and operating authorities are trying to expand services in poorly served areas, on equity grounds, and are therefore having to spread limited budgets more thinly.
* With privatisation and corporatisation now being the subject of considerable debate, and sometimes action, there is an increasing awareness of the lower cost levels of private operators: this is certainly true in Australia, and of course the UK. It has led to greater examination of what actions the public sector operators might take to improve their efficiency.
* With reduced emphasis on major system-expansion projects, more planning resources have become available to focus on making better use of the existing system.

These reasons have been behind increasing efforts to improve the efficiency and effectiveness of public transport systems, particularly those in the major urban areas where most of the money goes. But a pre-requisite of such efforts is to establish the efficiency and effectiveness of the present systems. Only then can the areas of poor efficiency and effectiveness be highlighted, to form a starting point for remedial action, and the success of any improvement effects be measured. Hence there is a need to initially establish, and then continuously monitor, the performance of public transport systems.

While most operators' managements have monitored performance for many years, their efforts have been typified by:

- a focus on financial reporting and control against budgets;
- a lack of clear objectives and associated quantified management targets (aside from budgets) against which to assess performance;
- an emphasis on the technical efficiency aspects of the operation, with a lack of monitoring of how well the services are meeting public needs (ie. effectiveness aspects).

Against this background, the New Zealand Minister of Transport decided to undertake a major Urban Bus Study in 1987/88. Travers Morgan was appointed to undertake the study, as Consultant to the Government's Urban Transport Council. The study was aimed at improving the efficiency and effectiveness of the bus services provided by the municipal operators in New Zealand's four main centres, ie. Auckland, Wellington, Christchurch and Dunedin. It followed the 1985 Urban Rail Review, which had identified substantial scope for efficiency savings in the urban rail systems in Wellington and Auckland (Gollin and Wallis, 1986).

One of the terms of reference for the Urban Bus Study was "to recommend a national set of performance measures applicable to major urban bus operators". This is not a trivial task. While there is an extensive literature on performance measurement in the urban public transport field, we were aware that to set up and maintain an effective and efficient system of performance monitoring, which can form a catalyst for improvement actions, is a difficult art and science. Yet we

were also aware from experience in many situations that such a system would be highly useful and, even if not perfect, could be a great improvement on the limited information readily available hitherto. (For instance, the availability of better information on operator efficiency and effectiveness would have given us a much better clue as to priority aspects for improvement within the Urban Bus Study than was possible with the limited information available at the time.)

This paper has therefore been partly prompted by our efforts to develop a system of performance monitoring applicable to urban bus operators in New Zealand. Section 2 following discusses the role of performance monitoring in urban public transport and guidelines for developing a monitoring system. Section 3 describes the system developed in the study and gives selected performance statistics for the four major New Zealand operators since 1980. These enable performance trends of each operator to be established and some comparisons between operators to be made (although a great deal of caution is needed in drawing conclusions from such comparisons). The system being developed is pragmatic rather than perfect and, at the time of writing, the work is not yet complete: some gaps and question marks remain in the data.

The four New Zealand operators examined show more similarities than differences in terms of style of operations, industrial conditions, etc. and hence in performance. However, in late-1987 I had the opportunity to examine in-depth a group of operators in a completely different situation. These were government operators of diesel/petrol bus, trolley bus, tram and urban rail services in three cities with a combined population of some 5 million, in Liaoning Province in northern China. This work was undertaken as part of a major appraisal of traffic and transport issues in the three cities for the purposes of securing a World Bank loan. My work included establishing a range of performance statistics for these operators over the last five years. Section 4 of the paper illustrates some of the considerable differences, and some similarities, between the performance of the New Zealand operators examined and these Chinese operators. Section 5 then presents brief conclusions.

2. PUBLIC TRANSPORT PERFORMANCE MONITORING - ROLE AND PRINCIPLES

2.1 Performance Monitoring - What is It?

Performance measurement is the process of measuring and analysing performance against stated objectives. Performance **monitoring** is the continuation of this process over a period of time in a systematic way.

For example, in the public transport context, if an operator has the objective of improving passenger safety, the extent of achievement of this objective might be monitored by regularly deriving statistics on passenger injury accidents per million vehicle kilometres.

It is evident that performance measurement and transport system objectives cannot be considered in isolation from one another. This inter-connection arises from the fact that objectives both determine the indicators used for performance measurement, and give meaning to the results of the evaluation. In the absence of adequate assessment of their implementation, objectives would become statements of principle divorced from day-to-day management decisions.

Experience is that the objectives of many (probably most) transit systems are imprecisely defined. In a perfect world, these would be better developed before any attempts are made to monitor performance against them. However, in practice, performance indicators may be developed to reflect aspects of system performance which would be relevant to any set of likely objectives, without these objectives having been formally defined and given priorities.

2.2 Why Monitor Performance?

Performance monitoring should form a key part of the overall corporate planning process in the transport sector. There is a need to monitor the performance of transport systems so as to ensure the service provided is both effective and efficient (see below). This monitoring process will establish performance trends and comparisons, and hence identify areas of inadequate performance as a precursor to further diagnosis and taking remedial action.

In the urban transport context in NZ, the **Urban Transport Act** (Clause 31.2) requires that:

> "The amount of any financial assistance offered or given by a regional authority to support the operation of an urban transport service shall not exceed the amount necessary to support the operation of an **efficient and economic** service of that kind".

For this reason alone, it is necessary for the central government (through the Urban Transport Council) and/or the regional authorities to have means of measuring the "efficiency and economy" of urban transport services. Both levels of government have interests in this regard, as both are involved in financial support to urban transport services. Both levels of government also have interests in ensuring that any subsidies achieve their defined objectives and do not lead to reduced efficiency and higher costs: hence there is a need to monitor service efficiency in terms of government subsidy policy (the monitoring of subsidy policies is discusses in more detail in Travers Morgan, 1988).

2.3 Performance Measurement Concepts

The concept of performance embraces two distinct notions - effectiveness and efficiency:

* **Effectiveness** is concerned with the output or results of the service. Actions are effective if the desired community objectives are achieved. Effectiveness indicators generally reflect the ability of the transport system to meet the goals set for it by the broader community or government interests.
* **Efficiency** is concerned with comparisons of the outputs of a system with the volume of resources consumed in obtaining them. Efficiency indicators essentially measure value (output) for money or other measures of resources input.

A suitable framework for examining transit performance relates **service inputs, service outputs** and **service consumption** by effectiveness and efficiency ratios, as illustrated in Figure 1 (Fielding et al, 1985).

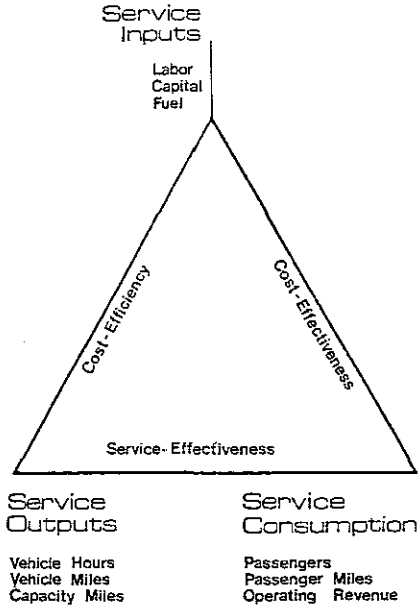

FIGURE 1: FRAMEWORK FOR A TRANSIT PERFORMANCE CONCEPT MODEL

The use of the performance concept involves making judgements on past or future actions. Prior to developing tools for performance assessment, it is first necessary to decide:

- to whom are they aimed?
- for what purpose are they to be used (efficiency or effectiveness)?
- is it possible to identify clearly the judgement criteria (efficiency) or the objectives (effectiveness)?

Often the answers to these questions are not simple, but are important if useful measures of performance are to be developed.

2.4 Performance Indicators

The performance of the system against any objective is measured by one, or more commonly several, **performance indicators** relating to that objective.

There are two groups of desirable qualities which may be expected of an indicator: intrinsic qualities and those which depend on the way it used.

Intrinsic Qualities:

* Relevance: the indicator should effectively express the point of view required, ideally without ambiguity.
* Validity: the degree of uncertainty about the variables contributing to an indicator should be minimal and known.

Qualities depending on use:

* Interpretation of variations: if the indicator is to account for changes in the object under consideration, then its variations should be able to be interpreted unambiguously.
* Interpretation of differences: if the indicator is to account for differences between two objects, it should show distinct values and the user should know which part of the observed difference is attributable to the phenomenon being analysed.
* Modelling: where possible, the indicator should be useful in describing the consequences of a possible decision.
* Decision-making qualities: the indicator should help users realise the importance of certain variables, and its significance should be readily understood in any decision-making process.

2.5 The Difficulties and Complexity of Performance Monitoring

The efficiency and successful monitoring of performance of transport systems is generally difficult and complex, particularly on account of three groups of factors:

* the multiplicity of parties involved
* the potential levels of analysis and disaggregation
* the variety of uses and difficulties of interpretation.

Multiplicity of Parties

There is typically a multiplicity of parties interested in performance of the transport system. Each party has different perspectives on transport performance, thus influencing the required number and nature of performance indicators. The interests of each party may be used as a basis for design of indicator packages.

The principal groups who may require transport performance data are as follows:

- Transport operator management: those responsible for efficient system performance.
- Transport authority policy boards (or others responsible for overseeing authority management): those responsible for seeing the system meets Government policy and community goals.
- Central and regional government financial, policy and planning authorities: those responsible for advising Government, implementing Government objectives and developing longer-term and strategic transport and land-use plans.
- Transport Minister (on behalf of Government): ultimately responsible for implementing Government objectives and disbursing funds.
- Transport users and local interest groups: those directly and regularly affected by the service (including disadvantaged residents).

- Transport authority personnel and their unions.
- Research community: those providing technical tools for transport management and planning.

Each of these groups has differing needs for performance indicators, by nature of their differing roles and functions in the transport system. The "art" of indicator development is to provide various packages of indicators which can efficiently and effectively meet the needs of each group and which may be derived by an economical process of data collection and analysis.

In the context of the work reported here, the needs of the first four groups above are of most direct relevance. Typically most monitoring of public transport systems currently undertaken focuses on the needs of operator management, and there is a general need for better monitoring suited to the needs of other interest groups.

Public transport operator management is typically interested in system operating efficiency and service planning. Management uses efficiency indicators to monitor trends in performance of the system, to compare performance in different parts of the system and to indicate trouble-spots possibly requiring remedial action. In addition, management and their boards will be interested in longer term planning and policy issues. The boards should also be concerned with effectiveness indicators measuring the system's achievement of a broader set of social, economic and political objectives.

Central and regional governments provide funds to transport authorities both for capital works and for operating assistance. In doing so, they expect assurances of effectiveness, efficiency and overall financial performance. They want to be assured that funds are being used wisely, that systems and investments are co-ordinated and that systems are contributing towards wider objectives (e.g. fuel conservation). Thus governments have an interest both in wider effectiveness indicators and in efficiency indicators. The level of detail at which they require such information will depend very much on the division of responsibilities between central government, regional government and the operating authorities.

Variety of Uses and Difficulties of Interpretation

Like any management and decision-making tool, performance indicators have a role in helping to forecast impacts of decisions, as well as in monitoring those aspects of the system which sometimes signal critical developments requiring action. Indicators may be useful, to transport operators, funding bodies and other parties, in the following ways:

- Helping to develop service goals and strategies, and to define and describe the system.
- Making possible the development of managerial and operational strategies.
- Testing trends in efficiency and effectiveness.
- Relating the system to its external environment.
- Monitoring progress towards stated objectives.

By necessity, the development of system objectives and their concomitant managerial actions are incremental, at both the authority and overall transport system levels. That is, objectives and actions must be continually updated, based on current performance as measured by appropriate indicators. Decisions can be made in terms of past performance, current performance and projected future performance. When appropriate data are available, decisions can be made relative to other transport modes.

However, performance indicators do have limitations and may be subject to problems of interpretation of their significance. Performance indicators merely **indicate** performance, rather than provide a comprehensive picture of efficiency, effectiveness, etc. Hence the concept of "packages" of performance indicators is appropriate, as discussed further below. Indicators need to be "packaged" and tailored to a given system environment if they are to be most effective. They

are perhaps most useful in trend analysis, enabling changes in performance to be highlighted - where appropriate with a view to triggering remedial action. They can measure the extent to which differing objectives are being attained and can form a basis for determination of realistic, quantified objectives. However, the use of performance indicators to compare between different modes of transport in different situations, or between different areas, is fraught with difficulties of interpretation. Despite these difficulties, some such comparisons are attempted later in this paper.

Potential Levels of Analysis and Disaggregation

As their name implies, indicators only **indicate** any variations from the norm or desirable outcome: they do not provide any diagnosis of the reasons for such variation. Thus, if a performance monitoring system is to be of practical use, it is necessary to be able to identify the causes of any such variations by investigations at a more detailed level, so as to provide the basis for corrective action. This leads to the concept of a **hierarchical system** of indicators; eg. the top level may be system-wide statistics for the operator, but these have been aggregated from costs for individual sections/cost centres, operating statistics from individual routes, etc. It is possible through disaggregation to identify in which part of the system the variations have occurred. The practical difficulty with this approach, as discussed below, is for operators to set up and maintain the appropriate hierarchical system in cost-effective way.

2.6 The Development of Indicator Packages

The Need for Packages. In view of the complexity of transport systems and the constraining nature of the indicator qualities required, it is in practice extremely difficult to construct a good single indicator to reflect performance against a given objective. Thus it is generally desirable to adopt a package of indicators, each of which has the required qualities only imperfectly, but which, taken together, compensate for any individual short-comings. The quality of any such package is determined not by the number of its constituent indicators, but by the internal consistency and complementarity of the indicators taken together. Much of the 'art' of performance measurement is thus to devise indicator packages which efficiently and effectively reflect the aspects of performance of interest.

Designing the Package. As noted earlier, the monitoring of transport system performance is complex and the potential range and amount of data that can be collected is extremely large. Different groups will wish to have access to different indicators and the way in which indicator packages can be most usefully put together naturally depends on the purposes for which they will be used. Even within a single transport authority, performance information may have several uses. For instance, indicators in a public transport authority may be required:

- in planning of new services, to help estimate the effects of particular changes;
- to show how successfully the operation is performing, and whether performance is improving over time; and
- to compare performance in different divisions of the authority.

Many of the indicators may be applied to all three purposes. Similarly, there will be an overlap between indicators used internally by the operator and those used in dialogue between the regional authority and the operator, or used for decision-making at different levels of government.

In deciding which indicators to include in a package designed for a particular purpose, two issues should be borne in mind. First, the collection of the necessary data and the calculation of the indicators may be costly in time and resources, even if all the data handling is computerised. Secondly, there is a danger that the really important information can become submerged under huge quantities of statistical data if the user is not sufficiently selective in deciding where to concentrate attention.

Thus it is important to tailor the package to the situation and to ensure that all data collected are justified by their usefulness to one or other of the interested parties. The objective should be to provide the minimum amount of information necessary to service adequately the various purposes to which it will be put.

Data Issues. Since indicators are only as valid as the information used to develop them, the approach to designing data elements and collection systems is critical to any performance monitoring system. Careful consideration needs to be given to this aspect, as data base development is costly and time-consuming.

Indicators are typically ratios, composed of figures obtained from some kind of information system and data base, financial and/or operational in character. In addition, data may be collected for special purposes to supplement the basic data system. The financial and operating data help to derive indicators concerning efficiency; and market statistics provide data primarily related to effectiveness.

Examination of the basic indicators provided may well suggest that more detailed investigation is required, so widening the data needs. Analysis of the financial and operational performance of a transport system is therefore a step-by-step process. When a particular aggregated indicator for the whole system diverges from a normal or target level, further analysis will be needed to track down the source of such divergence - as a preliminary to corrective action.

Thus a "hierarchical" data base system is required: data are generally collected and input at a detailed level, subsequently to be aggregated into more "global" indicators for monitoring by different levels of system management and other

interested parties. Regional or central government would generally be interested in the most aggregated form of data. Operator senior management would be interested in a less aggregate form, while (for example) depot managers would be interested in detailed data covering their area of responsibility. It is obviously essential that these various levels of indicator are derived from the same basic sources, assembled on a consistent basis.

One difficulty encountered here is that typically operators may be able to disaggregate their information in certain dimensions (eg. input costs can normally be broken down in considerable detail from general ledger sources); but are not readily able to provide disaggregate data in other dimensions useful for diagnosis and development of ameliorative measures. For instance, our experience is that information on operations, costs, patronage and revenue by route and time period is extremely useful in analysing the performance of an operation and diagnosing services requiring remedial action. Such information normally has to be derived by ad hoc studies, although some operators have now installed systems to undertake such analysis on a regular basis (e.g. State Transport Authority, South Australia, 1987). The current NZ Urban Bus Study includes some assistance in developing such systems for the major NZ municipal bus operators, and some one-off analyses to provide the required information.

Frequency and Reporting Issues. For each indicator, decisions need to be taken on the frequency with which the data is to be collected, analysed and reported: such decisions will have a major influence on the cost and time required for the procedures as well as on the usefulness of the outputs.

The desirable frequency of data collection is influenced by a number of factors, principally:

- The expected rate of change (and random variability) of the indicator.
- The expected significance of variations in an indicator over a given period, allowing for random and seasonal variability (e.g. changes in public transport patronage from day-to-day would generally not be significant, whereas annual changes would probably be so).
- The difficulty and cost of data collection and analysis.

In deciding on the desirable frequency, each indicator needs to be considered both separately and as part of a package. Often data may be conveniently collected on a frequent basis, but generally presented on an aggregated basis for monitoring purposes (e.g. patronage collected daily, summarised monthly): the basic data remain available if required.

In presenting information on changes in performance over time, the appropriate comparison will depend on the indicator concerned. For instance, where seasonal variations are expected (e.g. patronage), the current figure is best compared with the value for the same period of the previous year. Where there is no seasonal variation, comparison with the previous period is valid; but in all indicators there is likely to be some variation about the mean trend, so that calculation of the cumulative year-to-date figure is also likely to be of interest. For many indicators, comparison with a budgeted or target figure will also be appropriate.

Calculation of the many different indicators for each division of a large system will produce a large amount of data, and this may be produced at frequent intervals. There is a danger that this large amount of data can obscure the important issues: it is therefore important to give careful attention to how the data should best be presented for the purposes intended. This attention should include such matters as:

- best form of presentation - numerical, graphical;
- periods to be compared;
- parts of system to be compared;
- statistical tests required; and
- indications warranting action.

3. MEASURING THE PERFORMANCE OF NEW ZEALAND BUS OPERATORS

3.1 Overview of the Work

The development of a performance monitoring system as part of the NZ Urban Bus Study involved the following principal tasks:

(A) Definition of the objectives and scope of the system
(B) Appraisal of the existing performance measurement system and monitoring activities
(C) Review of relevant experience and practices elsewhere
(D) Development of system proposals
(E) Detailed system design (including computer procedures)
(F) Assembly of initial data and derivation of performance indicators.

This section of the paper briefly discusses tasks (A) and (D) and then presents results for a selection of the recommended indicators for the four municipal bus undertakings.

3.2 Objectives and Applications

As noted earlier, the work was required "to recommend a national set of performance measures applicable to major urban bus operators", in the context of the wider study aimed at improving the efficiency and effectiveness of the services provided by these operators. It also emerged during the study that a performance monitoring system should be able to help ensure that government subsidies to public transport are effectively directed to achieving their defined objectives and do not lead to reduced efficiency and higher costs: this was important in terms of the introduction of a more rational basis for subsidy allocation, which was the subject of a simultaneous study for the Urban Transport Council (Travers Morgan, 1988).

Within these broad objectives, it was seen that a performance monitoring system could potentially be useful in a number of applications:

i. To provide comparisons of efficiency/effectiveness **between operators** (cross-section comparisons). As noted earlier, such comparisons require considerable caution in drawing conclusions.
ii. To indicate **trends for an individual operator**. Analysis of aggregate trends (probably year-by-year) for an operator can indicate improvements or deteriorations in efficiency and be one signal of the need for corrective action.

iii. To provide comparisons of efficiency/effectiveness **between modes**. Although this is not of prime relevance to the Urban Bus Study, it is potentially a very useful application of performance monitoring.

iv. To **assist operators in management** and control of their undertakings. For instance, a set of operational/user performance statistics should be incorporated in the operator's budget and these be continuously monitored along with the financial statistics. It is only in this way that the causes of variations from budgets can be identified and corrective action taken.

v. To provide comparisons of **efficiency/effectiveness between different segments** of an individual operation, eg. by route group, peak versus off-peak. In our experience, such comparisons are extremely useful as inputs to service planning and policy development.

Following discussions with UTC about the scope and emphasis of the work, it was decided that the system should be directed primarily at applications (i) and (ii) above; and secondarily at applications (iii) and (iv).

It was recognised that application (v) is an important use of performance indicators, but that it would be an over-ambitious requirement at this stage for all operators to report results regularly on a service segment basis. This segmented analysis was undertaken during the study for Dunedin City Transport, and some assistance given to other operators towards developing appropriate analysis systems. This should be regarded as a separate, but related, activity to the establishment of a regular performance monitoring system at an operator-wide level.

As noted earlier, there is a variety of parties interested in performance monitoring, each having different requirements and needing different levels of aggregation of data. Following review and discussions, it was decided that the monitoring system for UTC should focus on:

* **annual** statistics;
* aggregate **operator** data, which can then be combined to provide area/regional data as required;
* using data that could be collected by operators on a regular basis, rather than that requiring special surveys (eg. many effectiveness indicators).

3.3 Selection of Performance Statistics

A set of 'basic statistics' and 'performance indicators' derivable therefrom was developed, in the light of the overall objectives of the project and the considerations outlined in Section 2, and following discussions with the operators about data availability, quality and interpretation and about their present monitoring procedures. In this context 'basic statistics' refers to the data as collected (eg. bus kilometres); while 'performance indicators' refers to the ratio between basic statistics (eg. costs per bus kilometre).

The initial list of **basic statistics** specified for each operator, on an annual basis, is as follows:

- Total buses
- Peak bus requirement
- Total bus kilometres

- Total bus hours (ex-depot)
- Total employees
- Driver shifts per weekday
- Working expenses
- Total operating costs (working expenses and capital charges)
- Capital expenditure
- Passenger boardings (fare services/other/total)
- Passenger kilometres
- Revenue (fare services/other/total)
- Fuel consumption
- Breakdowns in traffic
- Personal injuries
- Network kilometres
- Service area population.

The **performance indicators** to be derived from these basic statistics were as follows:

* **Network Characteristics**
  - Bus kilometres: network kilometres (measure of average service frequency)
  - Bus kilometres: population

* **Vehicle Supply**
  - Population: total buses
  - Total buses: peak buses
  - Average vehicle age

* **Vehicle Productivity**
  - Bus kilometres: peak buses
  - Bus hours: peak buses
  - Bus kilometres: bus hours (ie. average speed)
  - Fuel consumption: bus kilometres

* **Employee Productivity**
  - Employees: peak buses
  - Bus kilometres: employees
  - Weekday driver shifts: peak buses

* **Operational Performance**
  - Bus breakdowns in traffic: bus kilometres
  - Personal injuries: bus kilometres

* **Cost Productivity**
  - Working expenses: bus kilometre
  - Working expenses: bus hours
  - Working expenses: peak bus

* **Passenger Efficiency**
  - Passenger boardings: population
  - Passenger boardings: bus kilometres
  - Passenger boardings: bus hour

- Passenger boardings: peak bus
- Passenger kilometres: bus kilometres (ie. average load)
- Passenger kilometres: passengers (ie. average trip length)

* **Revenue Earning**
  - Fare revenue: passenger boarding (ie. average fare)
  - Fare revenue: passenger kilometres
  - Total revenue: bus kilometres
  - Total revenue: peak bus.

* **Cost Effectiveness**
  - Working expenses: passenger boardings
  - Working expenses: passenger kilometres

* **Cost Recovery and Subsidy**
  - Total revenue: working expenses
  - Total operating cost - total revenue (ie. 'subsidy')
  - Subsidy: bus hours
  - Subsidy: passenger boarding
  - Subsidy: passenger kilometre
  - Subsidy: population.

While this list is perhaps larger than might be desirable, it does provide 'packages' of indicators which together provide a reasonable, balanced description of efficiency or effectiveness under the various headings adopted. Three other points about the specified indicators should be made:

* Because of data limitations, the list is far from ideal in its coverage of various aspects of performance. In particular, more and better indicators of service effectiveness (to passengers) would be desirable.
* Two key statistics in the list are difficult for operators to determine accurately with current systems: these are bus hours and passenger kilometres. However, we believe their importance as basic measures of service supplied and service usage (respectively) is such that they should be included, even if the estimates are inprecise in some cases.
* For trend (year-by-year) analysis, all financial indicators have been expressed in real terms, adjusted by CPI figures.

3.4 Some Performance Findings

The basic statistics specified in the previous section have been assembled for the four New Zealand municipal operators for years 1979/80-1987/88 (some statistics were not available and in other cases estimates had to be made). The required performance indicators, as listed above, were then derived.

A selection of these indicators is presented in Figure 2 (lack of space prevents the complete 'package' of indicators being shown). Brief comments on some of the key features of these results are now given.

* **Figure 2.1.** Indicates the relative sizes of the four operations (as measured by total bus kilometres).

* **Figure 2.2.** Shows annual trips per head (within the service area): the much higher trip rates in the larger cities, with more congestion and more difficult parking, are notable.

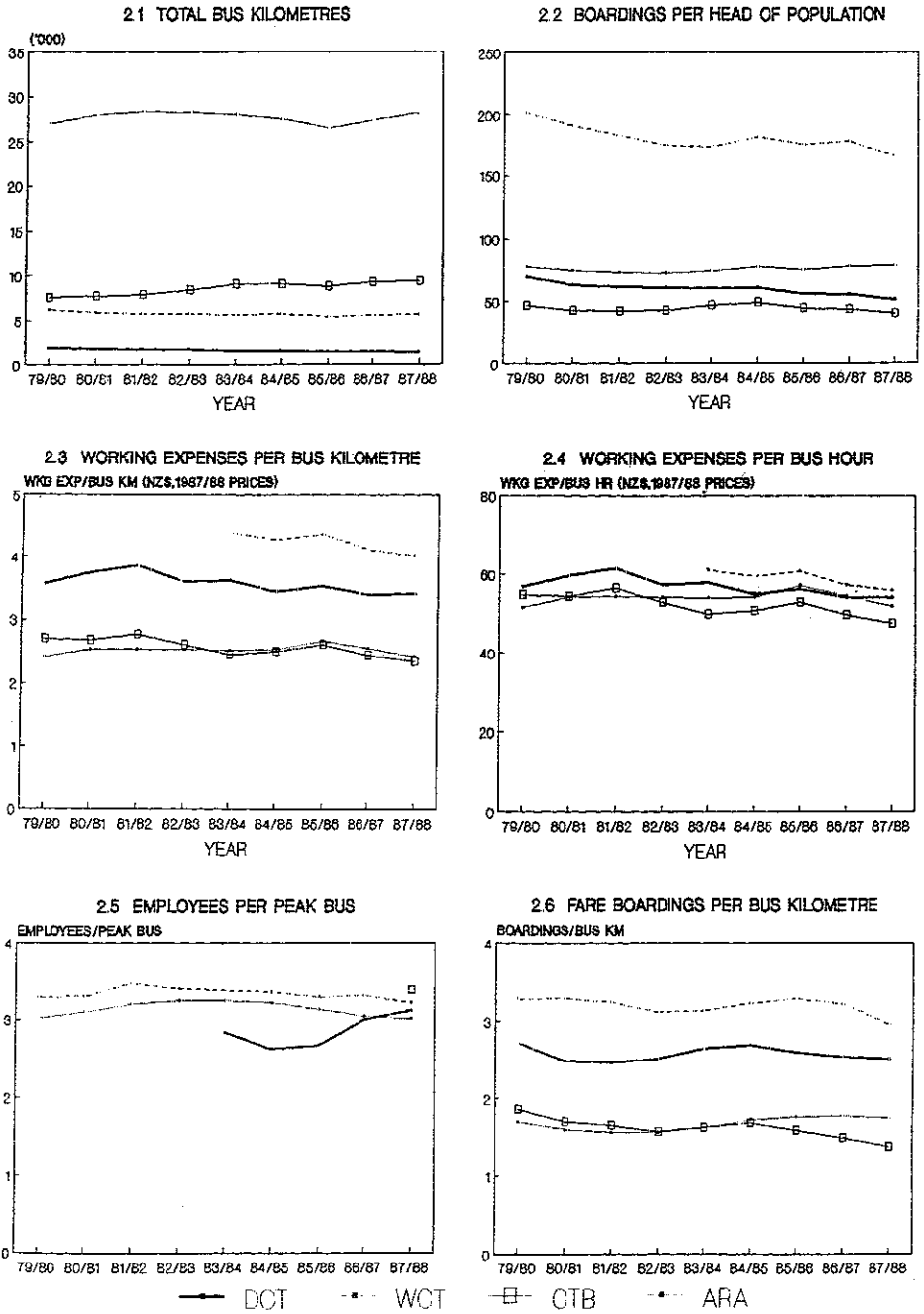

FIGURE 2: NZ MUNICIPAL BUS OPERATORS - PERFORMANCE INDICATORS 1979/80 - 1987/88

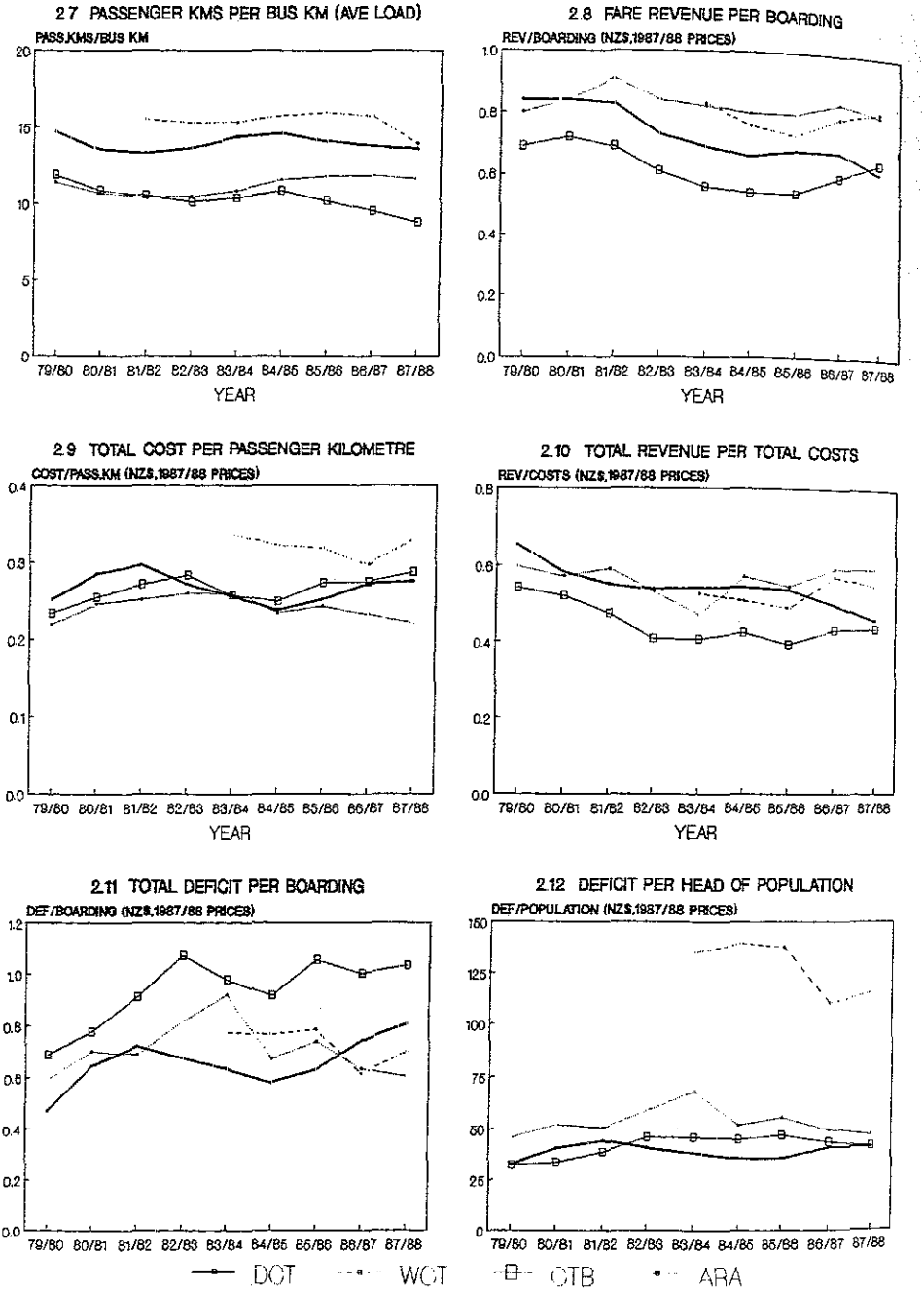

FIGURE 2 (Cont.): NZ MUNICIPAL BUS OPERATORS - PERFORMANCE INDICATORS 1979/80 - 1987/88

* **Figure 2.3.** Indicates a considerable range in costs per bus kilometre, with Wellington being highest (greatest congestion and also includes trolley buses).

* **Figure 2.4.** The costs per bus hour are much closer than the costs per bus kilometre and provide a better measure of overall cost-efficiency (more costs are time-dependent than distance-dependent).

* **Figure 2.5.** This is a useful aggregate measure for inter-operator comparison. The differences between operators are small.

* **Figure 2.6.** Also a useful measure for comparisons between operators. The lower-speed operators (WCT, DCT) have higher boarding rates per bus kilometre, but the boarding rates per bus hour would show less difference. CTB's fall in boarding rate over the period (by over 25%) is notable.

* **Figure 2.7.** This is another useful comparative measure between operators. The trends are similar to the previous graph. The difference between operators is substantial: the highest average figure (WCT) is 14.0 and the lowest (CTB) is 8.8.

* **Figure 2.8.** This is the average fare (real terms). In most cases real fares have declined over the period.

* **Figure 2.9.** This is a useful indicator for comparing across a variety of modes and operators. Particular features are:
  - the higher costs of WCT (difficult operating conditions)
  - the improvement in performance of ARA in the last few years, due to some increase in average loadings and containment of unit costs.

* **Figure 2.10.** These cost-recovery figures combine the effects of a number of the previous indicators (cost levels, boardings, fare levels etc). The current cost-recovery levels are in the range 43%-60%, somewhat higher than those of the major Australian public sector operators.

* **Figure 2.11.** Shows substantial variations in trends and performance of the four operators.

* **Figure 2.12.** This indicator is of considerable importance in the allocation of central government funds between regions. Two particular features are:
  - the deficit per head has been reasonably well contained (in real terms) over the last 10 years
  - the Wellington figures are much higher than in the other cities, reflecting the higher trip rates and the higher cost levels.

These brief comments on only a selection of the indicators cannot give a full picture of the potential usefulness of the data. Indeed, the system is only just being set up and all its possible applications have not yet been explored. However, the data collected and the indicators derived for the four operators are already proving of considerable value in diagnosing problems and highlighting aspects for attention in the Urban Bus Study.

4. COMPARATIVE PERFORMANCE IN DEVELOPING COUNTRIES - SOME CHINESE FINDINGS

As noted in the Introduction, in late 1987 an in-depth examination was undertaken of the performance of urban public transport services in three cities in northern China, as part of a major transport and traffic study. The 'conventional' public transport services in the three cities comprise:

- diesel/petrol buses (many articulated)
- trolley buses (mostly articulated)
- trams
- suburban trains (generally operating in 7-car units).

These Chinese cities are characterised by:

* high densities of population
* low car ownership, but high bicycle usage (resulting in the proportion of all trips by public transport being not much higher than in New Zealand or Australian cities)
* considerable congestion affecting buses, particularly due to the amount of cycle traffic
* very high service frequency (often buses every 1-2 minutes in the peaks), on a limited number of routes
* demand levels at weekends similar to those on weekdays (Saturday in generally a working day, Sunday the only shopping/leisure day for many workers)
* insufficient public transport vehicles, due to restricted production and capital shortages, resulting in very high loadings and considerable overcrowding.

Working with the local operators, we established a set of performance indicators for years 1982-1987 broadly comparable with those listed in the previous section for the New Zealand bus operators. Table 1 shows some of the key indicator results for each of the Chinese operators and gives the corresponding New Zealand figures for comparison. The figures given relate to the latest available year in each case, generally 1987 calendar year or 1987/88 financial year.

Great caution is obviously needed in trying to compare the performance of operations in such differing situations. However the results do clearly show some of the key differences between urban public transport in a developing country such as China and in more developed countries, such as New Zealand or Australia.

Some notable features of the Table 1 results are as follows:

* Average service frequency in the Chinese cities (Indicator 1) is in the order of five times that for the New Zealand operators.
* The 'passenger efficiency' of the Chinese services is in the order of **five times** that of the New Zealand services. Boarding rates (Indicator 9) of the Chinese bus services are typically 10-15 passengers per kilometre, while the New Zealand rates are 1.5-3.0. Similarly, average loadings in New Zealand (9-14 per bus) may be compared with the **average** Chinese loadings of 50-80 per bus (using a high proportion of articulated vehicles)! The typical Chinese peak bus carries 1500-2000 passengers per day, while the NZ buses carry about 250 passengers per day (Indicator 11).

TABLE 1: PERFORMANCE INDICATORS: NZ MUNICIPAL BUS OPERATORS AND CHINESE URBAN TRANSIT SERVICES

Indicator	NZ				Anshan				Fushun			Shenyang		
	DCT	CTB	WCT	ARA	Bus	Trolley	Tram	Total	Bus	Train	Total	Bus	Trolley	Total
1. Veh Kms/730: Network Kms(1) (ave frequency)	-	40	58	57	-	-	-	354	-	-	193	-	-	233
2. Population: Total Vehicles	1220	1790	450	1170	-	-	-	2480	-	-	1830	-	-	2510
3. Average Veh Age	-	-	-	-	11	8	26		13	28		9	12	
4. Veh Kms: Peak Vehs	35,600	58,100	30,900	59,600	57,500	55,100	55,000		54,900	71,300		43,600	47,700	
5. Veh Kms: Veh Hours (ave speed)	16.0	20.3	14.0	21.4	13.8	15.2	13.1		14.7	23.1		13.8	13.0	
6. Employees: Peak Veh	3.1	3.4	3.2	3.0	15.6	-	-		14.7	36.3		14.7	16.3	
7. Pass/Day: Population (trip rate)	0.14	0.11	0.45	0.21	-	-	-	0.62	-	-	0.95	-	-	0.67
8. Pass Kms: Passengers (ave trip length)	5.4	6.4	4.7	6.7	5.6	3.2	3.5		5.7	8.3		5.9	4.8	
9. Pass: Veh Km (boarding rate)	2.5	1.4	3.0	1.7	9.0	15.2	18.2		14.3	6.3		13.4	15.5	
10. Pass Kms: Veh Kms (ave load)	13.6	8.8	14.0	11.7	50.1	47.8	62.7		81.3	52.0		78.4	74.4	
11. Pass/Day: Peak Vehs	240	220	250	280	1420	2290	2740		2040	1220		1600	2030	
12. Pass: Employees	28,500	23,500	28,500	34,400	33,300	-	-		50,800	12,300		37,800	43,000	
13. Total Revenue: Total Costs	0.46	0.44	0.55	0.59	-	-	-	0.74	0.97	0.66	0.89	0.91	0.99	0.95

Notes: (1) This represents the average daily number of transit vehicles passing (in one direction) along each section of road served.

* These high loadings on the Chinese services reflect an inadequate supply of buses. The Chinese cities average about one public transport vehicle per 2000-2500 people, while the New Zealand cities typically have 1 vehicle for about 1000 people (Indicator 2).
* Despite this, the average daily trip rates (Indicator 7) for the Chinese cities are in the range 0.62-0.95, whereas those for New Zealand are much lower.
* Employee productivity in relation to service output is much higher in New Zealand. The employees: peak vehicle ratio (Indicator 6) in New Zealand is typically 3.0-3.5, while that for the Chinese bus operators is about 15 (most of the vehicles are articulated and generally have two or three conductors per vehicle).
* Employee efficiency in terms of passengers: employees ratios (Indicator 12) is similar in the two countries. The higher employees: peak vehicle ratio of the Chinese operators is offset by their much higher passengers: peak vehicle ratio.

Perhaps the most striking feature of these findings is the vastly higher 'passenger efficiency' of the Chinese services. The average vehicle loadings in the Chinese cities are in the order of five times those in New Zealand; and, despite this, the average service frequency is also in the order of five times higher. In aggregate, the Chinese level of demand (per route kilometre) is 20-30 times that in the New Zealand situation. I am sure many New Zealand and Australian operators would like to be in the position of having the demand levels of their Chinese counterparts!

5. CONCLUSIONS

This paper has been concerned principally with the development of a system to assist the New Zealand government (through the Urban Transport Council) in monitoring the performance of the major municipal bus operators in New Zealand. Such a system is directed at assessing the efficiency and effectiveness of these operators, with the main objectives being to help identify areas of poor performance and to provide a catalyst for improvements in these areas. The system will enable performance to be examined in a number of ways - particularly trends for an individual operator over a number of years, and comparisons between operators (and between modes if the system is extended).

The system is currently in its early stages of development, is far from perfect and is heavily constrained by the availability of regular data, especially in relation to service effectiveness aspects. However, it is a considerable advance over what went before and is already proving of value in identifying priority areas for pursuing efficiency and effectiveness improvements.

6. ACKNOWLEDGEMENTS

The work described in this paper has been undertaken by Travers Morgan Pty Ltd in two consultant studies:

* Urban Bus Study, for the NZ Urban Transport Council in conjunction with the four major municipal bus operators (Auckland Regional Authority, Christchurch Transport Board, Dunedin City Council Transport Department and Wellington City Council Transport Department).

* Liaoning Province Traffic and Transport Project, for the Liaoning Urban Construction Engineering Consultant Corporation, in conjunction with the public transport operators in Shenyang, Anshan and Fushun.

Thanks are due to the clients of both studies for permission to publish this paper. The sole responsibility for the paper lies with the author.

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