AN URBAN TRANSIT FIRM PROVIDING TRANSIT, PARATRANSIT AND CONTRACTED-OUT SERVICES

A Cost Analysis

By Wayne K. Talley and Eric E. Anderson*

I. INTRODUCTION

During the decade of the 1970s, the transit industry in the United States was transformed. From being primarily private it became primarily public: the proportion of publicly owned transit firms increased from 15 to 55 per cent between 1970 and 1980 (Transit Fact Book, 1981, p. 43). At the same time, public transit firms received a major infusion of government capital and operating subsidies. Consequently, transit operating deficits increased from $288.2 million in 1970 to $3,946 million by 1980 (Transit Fact Book, 1981, pp. 46–47). As these deficits were likely to increase further in the 1980s, governments have sought to stabilise or reduce them. As operating subsidies shrank or were likely to shrink, public transit firms have been forced to consider other ways to reduce their operating deficits. These methods have been classified as either being traditional or non-traditional (see Teal, Giuliano and Brenner, 1983).

The traditional method used by transit management to reduce operating deficits is to use strategies related to the present structure of service, that is, to increase fares and/or to decrease service costs. Strategies for reducing service costs include, for example, reducing the level of service and using a higher proportion of part-time labour in order to reduce labour costs.

The non-traditional method by which transit management can reduce operating deficits is to replace segments of the firm’s present mass transit service with less costly new services. These new services have generally been paratransit rather than new mass transit services. Traditional services provided by urban transit firms have been mass transit services. Mass transit service is fixed-route or variable-route passenger service available to the public. Paratransit service is any combination of scheduled or non-scheduled and fixed-route or variable-route passenger service available to the public except for the combination of fixed-route, scheduled passenger service which constitutes mass transit service. Examples of mass transit services include motorbus, heavy rail, and light rail services; examples of paratransit services include dial-a-ride and van pool services.1 Under the non-

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1 For further discussion of mass transit and paratransit services, see Talley (1983).
traditional approach to reducing transit operating deficits, services have not only been provided by the transit firm but they have also been contracted out to private providers (the firm pays a private firm to provide the service) or turned over to a private provider (without compensation from the transit firm).

The purpose of this paper is to analyse the cost structure of a non-traditional (but increasingly important) transit firm: that is, a paratransit-transit firm that provides both mass transit and paratransit services as well as contracted-out service. An empirical cost equation is estimated for such a firm and then analysed. Since it has been argued that the traditional strategies for reducing transit operating deficits of mass transit services, such as fare increases or service reductions, do not affect the underlying problem of escalating costs, it is obviously important to understand the cost structure of the non-traditional firm, which does attack the problem of escalating costs.

The authors believe this paper is the first to present an empirical cost equation of a multiservice transit firm. It is also the first to present a detailed cost analysis of a multiservice transit firm providing both transit and paratransit services, the paratransit service including both demand-responsive and commuter types. Finally, it is the first to discuss in detail the cost reduction effected by contracting out one of the services of a multiservice transit firm.

Since the types of paratransit and contracted-out services vary widely among transit firms that run them, this paper was forced to rely upon the data of an individual transit firm, the Tidewater Transportation District Commission (TTDC). The next section describes the service structure of the TTDC. The following section explains how the TTDC has lowered the cost of its motorbus service. Then we show the general and specific forms of the cost function estimated, as well as a priori signs. This section presents the empirical results. The final section gives the conclusions of the discussion.

II. SERVICE STRUCTURE OF THE SELECTED FIRM

The TTDC is a government (or public) agency chartered in the Commonwealth of Virginia to plan, operate and regulate public transport services. Five cities — Chesapeake, Norfolk, Portsmouth, Suffolk and Virginia Beach — are members of the TTDC and receive public passenger transport service from it. The TTDC as a public agency is eligible for and receives capital subsidies from the federal government, as well as from the Commonwealth of Virginia; in addition, operating subsidies are provided by the federal government and by the five member cities of the commission out of general revenue funds.

The TTDC is responsible for the provision of four general public passenger transport services: (1) motorbus mass transit service; (2) dial-a-ride paratransit service; (3) subscription paratransit service for the elderly and handicapped; and

\[\text{Demand-responsive paratransit services are those that are flexible in time or are non-scheduled. They may be either non-scheduled, variable-route services such as dial-a-ride or non-scheduled, fixed-route services such as the jitney. Commuter paratransit services are forms such as van pool, which follow a fixed time schedule but a variable route.}\]

354
(4) van pool paratransit service. For the provision of fixed route, scheduled bus service (that is, motorbus mass transit service), the TTDC is a medium-sized system in comparison with other motorbus service systems in the United States. Specifically, the TTDC has forty-six motorbus routes, using a fleet of 168 motorbuses.

TTDC's dial-a-ride paratransit service is a shared-ride taxi service; it is offered to low-density residential areas as a feeder service to motorbus routes and as a substitute for evening and weekend motorbus services. Dial-a-ride paratransit service is generally defined as a shared-vehicle service which provides door-to-door service on demand to a number of travellers with different origins and destinations. Dial-a-ride service is a type of demand-responsive paratransit service, since it is flexible in time and non-scheduled. The request for TTDC's dial-a-ride service is made by telephone. Furthermore, the dial-a-ride service is not actually provided by TTDC, but is contracted out to private taxi companies to which TTDC pays a fee for the number of hours of service provided. Since the inception of the service, TTDC has considered dial-a-ride as a lower cost alternative to its motorbus service; some marginal motorbus routes or segments of marginal motorbus routes have been withdrawn and replaced by dial-a-ride service in the relevant areas. Fearful for loss of jobs, motorbus operators have opposed implementation of dial-a-ride service; and Local Division 1177 of the Amalgamated Transit Union, AFL-CIO, which is the collective bargaining agent for these union employees, has sought to limit provision of the service.

TTDC's subscription paratransit service for the elderly and handicapped is a service that is under contract with public and non-profit agencies. The agencies determine the actual level of service; prospective passengers request service from the agency directly, and the TTDC provides the actual service (using TTDC vehicles and operators). Specially equipped van vehicles for the handicapped and elderly are used. This service is similar to dial-a-ride paratransit services, except that requests for passenger service are made direct to the contracting agencies rather than to the TTDC. It differs from TTDC's dial-a-ride service because it is actually provided by TTDC under contract to an agency, whereas the dial-a-ride service is contracted out to and provided by local taxicab companies.

TTDC's van pool paratransit service is a vehicle-leasing service. The TTDC leases TTDC vans (and in some cases small buses), but not operators, to individuals for a stated length of time (usually for a year). The lessee finances the cost of the lease with TTDC by forming a group of people who use the vehicle for work (or commuter) or non-work (or non-commuter) trips and who pay the lessee a fee for each trip. Usually, the passenger fee structure is set up so that the lessee receives free transport. The TTDC incurs costs in managing this vehicle-leasing service, as well as the insurance and maintenance costs of leased vehicles.

3 For a discussion of taxicab operations and costs, see Gilbert, Burby and Feibel (1984) and Pagano and McKnight (1983).

4 For a discussion of private provision of transit services, see Viton (1981b, 1982a, 1982b).

5 This service may also be referred to as a demand-responsive paratransit service.

6 For a discussion of a shared vehicle fleet, see McCarthy (1984).
III. LOWER COST ALTERNATIVES, WORK RULES, AND SCHEDULING

Over the time period of this study (1979–1984), the TTDC has lowered the cost of its motorbus service by: (1) providing a lower-cost substitute service (that is, the contracted-out service, dial-a-ride), (2) placing minibuses driven by lower-wage operators on selected motorbus routes, (3) reducing overtime pay of motorbus operators (through work-rule concessions by the operators and resulting in improvements in motorbus schedule efficiency), and (4) obtaining a multiyear wage-tier concession from motorbus operators. These events have occurred in the order stated over time. It is argued in the following discussion that the first action, the contracting out by the TTDC of the dial-a-ride service, contributed to making possible the subsequent three methods of saving costs: that is, the initial contracting out of service has had a cost-saving spiral effect on motorbus service.\(^7\)

In 1979 the TTDC was awarded a National Ridesharing Demonstration Program project for the development of shared-ride taxi services in selected areas. This project was the impetus for the TTDC’s dial-a-ride paratransit service. Under the project, twelve shared-ride taxi service areas were established, and the service was contracted out to local taxicab companies. In six of the twelve established service areas the taxis did not replace motorbus service routes but rather provided a new public transport service; in four areas they replaced the weekday and weekend service of four motorbus service routes; and in two service areas they replaced the evening service along three motorbus service routes.\(^8\) The elimination of motorbus service routes and their replacement by shared-ride taxi service areas meant that a high cost service was replaced by a lower cost service. Hence the operating expenses of the TTDC were lowered by decreasing motorbus service and increasing shared-ride taxi service. Also, where evening and weekend motorbus services were replaced by shared-ride taxi service, the TTDC’s operating management was able to reduce the overtime pay of motorbus operators.

The threat of further contracting out of service and pressure from local government to lower TTDC’s costs enabled the TTDC to obtain work-rule concessions from the union. In the Memorandum of Agreement between the TTDC and the Amalgamated Transit Union for 1982/83 (see the Appendix), two significant concessions were obtained. First, all regular motorbus runs (that is, runs by regular operators) must be a minimum of 7.5 hours per day instead of the

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\(^7\) This contention is also supported by the perfectly contestable market theory that (to paraphrase) the threat of potential new entrants in a market may limit price increases or reduce prices charged by incumbent firms. In our case, the threat that the TTDC might contract out further service, and thus the threat that motorbus-operators might lose jobs, have induced incumbent motorbus operators to accept wage concessions and other TTDC cost-saving proposals. For a discussion of perfectly contestable markets, see Baumol (1982) and Bailey and Friedlander (1982).

\(^8\) The TTDC has a total of 48 motorbus routes, so only a small proportion of its motorbus routes were replaced by dial-a-ride service. The simple correlation between motorbus miles and dial-a-ride miles is 0.00892; thus the implicit assumption of independence between these two variables is reasonable.
previous minimum of 8 hours per day. Second, the union agreed to allow the TTDC to establish a minibus operator position and a minibus division, which would provide minibus service and would be a part of the bargaining unit. Minibus service was defined as new dial-a-ride service and service using minibuses (that is, vehicles smaller than conventional motorbuses). Van pool and special transport services for the elderly and handicapped were excluded from the definition of minibus service. Minibus operators were defined as furloughed and/or new employees who are paid a lower wage rate and entitled to less holiday and vacation time than regular motorbus operators; also, they are not entitled to pay (as are regular motorbus operators) for such non-inservice times (that is, times when they are not actually driving) as, for example, report time, time for meals, travel time and spread time. In return for these concessions, the union received a concession from management in future restrictions on contracting out of services (see the Appendix, Section IIC9).

According to the TTDC’s scheduling supervisor, the reduction in the minimum-hour day from 8 to 7.5 hours has allowed his department to make a significant reduction in the overtime (or penalty) pay of motorbus operators. It has allowed the scheduling department greater flexibility in the construction of weekly runs for operators, in which overtime hours are significantly reduced. This reduction is reflected in the ratio of overtime (or penalty) hours to inservice (or driving) hours for motorbus service. In Table 1 these ratios were computed for typical weeks selected by the scheduling supervisor. For the weeks in the period from September 1981 to July 1982, the ratio is approximately 0.04; for a typical week in February 1983, the ratio is 0.02 (that is, the ratio was cut in half).

During the time period of this study (1979–1984) the TTDC did not use bargaining-unit labour to provide dial-a-ride service because the service was always contracted out. But on a few selected motorbus routes it has used a limited number of minibuses with minibus bargaining-unit labour. The service is still considered motorbus service, since it is scheduled, fixed-route service; furthermore, both minibuses and conventional motorbuses are used on the selected routes. When minibuses and their operators replace conventional motorbuses and their operators, the cost of motorbus service is lowered because minibus operators do not receive compensation for non-inservice hours, but conventional motorbus operators do. Thus there is an increase in the ratio of in-service hours to pay hours. This improvement in efficiency is depicted in Table 1. Before February 1983, the ratio of inservice hours to pay hours ranged from 0.848 to 0.898; in February 1983 and July 1984 it ranged from 0.926 to 0.923.\(^9\) One would also expect to see a decrease in the ratio of non-inservice hours to inservice hours, as shown in Table 1.

The concern of the union over the contracting out of service is also evident in the Memorandum of Agreement between the TTDC and the Amalgamated

\(^9\) This ratio is used as a measure of schedule efficiency in Chomitz and Lave (1984). It is worth noting that the TTDC schedule efficiency of 0.926 in Table 1 is higher than any actual or simulated value (using part-time labour) for schedule efficiency that appears in Chomitz and Lave (1984).
TABLE 1

Motorbus Time Comparisons

<table>
<thead>
<tr>
<th>Time Period</th>
<th>PH/ISH</th>
<th>NON-ISH/ISH</th>
<th>ISH/PYH</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 1980</td>
<td>0.104</td>
<td>0.075</td>
<td>0.848</td>
</tr>
<tr>
<td>September 1981</td>
<td>0.036</td>
<td>0.078</td>
<td>0.899</td>
</tr>
<tr>
<td>December 1981</td>
<td>0.039</td>
<td>0.077</td>
<td>0.896</td>
</tr>
<tr>
<td>February 1982</td>
<td>0.043</td>
<td>0.076</td>
<td>0.893</td>
</tr>
<tr>
<td>July 1982</td>
<td>0.044</td>
<td>0.081</td>
<td>0.889</td>
</tr>
<tr>
<td>February 1983</td>
<td>0.020</td>
<td>0.060</td>
<td>0.926</td>
</tr>
<tr>
<td>July 1984</td>
<td>0.020</td>
<td>0.063</td>
<td>0.923</td>
</tr>
</tbody>
</table>

PH/ISH is penalty hours divided by inservice hours; NON-ISH/ISH is non-inservice hours divided by inservice hours; and ISH/PYH is inservice hours divided by pay hours. Pay hours are the sum of penalty hours, inservice hours, and non-inservice hours.

Transit Union for 1983–1986. A number of restrictions on the contracting out of service by the TTDC are specified (see Appendix, Section IIID). In return, the union agreed to an eight-year wage-tier system, under which an operator would have to work for the TTDC for eight years before receiving the top wage rate (see the Appendix, Section IIIB).

IV. THE COST FUNCTION

Since quarterly time series data from a single firm (the TTDC) are to be used to estimate the parameters of a cost function, it is generally argued that one is assuming the cost function to be a short-run cost function. This follows, since, over the unit time period of the times series data, it is generally not possible for the firm to adjust the levels of some resource factors such as capital, for example, to minimise long-run costs. Hence, we view TTDC’s numbers of vehicles as fixed resource factors, and we estimate TTDC’s short-run variable cost function.

Specifically, the general form of TTDC’s short-run variable cost function whose parameters we intend to estimate can be written as:

$$ C = C(Q_{im}, Q_{ebm}, Q_{em}, Q_{dm}, P_i, P_f, V_i, V_o) $$

(1)
where

\[ C \] represents the short-run variable cost of operating expenses of the TTDC;

\[ Q_{tm} \] = motorbus miles of service provided by the TTDC;

\[ Q_{ehm} \] = elderly and handicapped paratransit service miles provided by the TTDC;

\[ Q_{vm} \] = van pool paratransit service miles provided by the TTDC;

\[ Q_{dm} \] = dial-a-ride paratransit service miles provided by the TTDC;

\[ P_l \] = the price of labour for TTDC;

\[ P_f \] = the price of fuel for the TTDC;

\[ V_t \] = the number of motorbuses owned by the TTDC; and

\[ V_o \] = the number of vehicles other than motorbuses (i.e. van pool vans, vans for the elderly and handicapped, cars etc.) owned by the TTDC.

In the estimation of cost functions of transport firms, the literature has generally assumed that their specific forms are one of three forms: (1) a translog function; (2) a loglinear function; and (3) a linear function (see Talley, 1984, chapter 3). The translog cost function is a member of the class of flexible cost-function forms; alternatively, loglinear and linear cost functions are members of the class of non-flexible cost-function forms. Specifically, non-flexible cost functions place restrictions on the nature of the underlying production technology of the transport firm (see Christensen, Jorgensen and Lau, 1973). Alternatively, flexible cost functions allow for a greater degree of generality by placing fewer restrictions (than non-flexible cost functions) on the nature of the firm’s underlying production technology. The translog cost function, for example, is a flexible cost function, as it serves as a second-order approximation to an arbitrary technology; that is, it can be viewed as a second-order Taylor’s series expansion in the logarithms of the variables contained in the general form of the cost function. The loglinear and linear cost functions are non-flexible cost functions, as they assume Cobb-Douglas and fixed proportions production technologies respectively (see Talley, 1984, chapter 3).

Though the translog cost function specification is generally preferable to the loglinear and linear cost function specifications (as explained above), it has a drawback when applied in empirical research – it requires a relatively large sample. Specifically, a larger number of parameters would have to be estimated if equation (1), for example, were specified as a translog cost function rather than as either a loglinear or a linear cost function. Since no relatively large sample was available for the purpose of this paper, the authors were unable to consider the translog cost function specification. Both the log-linear and the linear cost function specifications were considered. Since the statistical results of the log-linear specification were superior to those of the linear specification, only the results related to the loglinear specification are presented. Furthermore, the cost structure restrictions of the loglinear cost function are less restrictive than those of the linear cost function; also, the loglinear cost function is a special case of the translog cost function (see Talley, 1984, chapter 3).

A loglinear cost function specification of equation (1) can be expressed as:
\[
\log C = a_0 + a_1 \log Q_{em} + a_2 \log Q_{ebm} + a_3 \log Q_{vm} + a_4 \log Q_{dm} \\
+ a_5 \log P_I + a_6 \log P_f + a_7 \log V_t + a_8 \log V_o
\] (2)

The coefficient parameters (that is, the coefficients \(a_1\) through \(a_8\)) are interpreted as partial cost elasticities with respect to the explanatory variables in question. Furthermore, these coefficients are partial derivatives of \(\log C\) with respect to the natural logarithm of the explanatory variables in question. Hence, for example, the coefficient parameter \(a_1\) would be interpreted as the percentage change in short-run variable cost to be expected from a given percentage change in motorbus miles of service, with the values of the remaining explanatory variables held constant. For instance, a value of 0.5 for \(a_1\) would imply that a 10 per cent increase in motorbus miles of service would be expected to increase the short-run variable cost of the firm by 5 per cent, with the values of \(Q_{ebm}, Q_{vm}, Q_{dm}, P_I, P_f, V_t,\) and \(V_o\) remaining constant.

The \(a\ priori\) signs for the parameters \(a_1, a_2, a_3, a_5,\) and \(a_6\) are positive; that is, increases in TTDC's motorbus, elderly and handicapped paratransit, or van pool paratransit services, or an increase in the price of labour or fuel, would be expected, other things being equal, to increase the operating expenses (or short-run variable cost) of the TTDC. The \(a\ priori\) signs for the parameters \(a_7\) and \(a_8\) are negative; that is, an increase in buses or other vehicles owned by the firm is expected to decrease operating expenses.

The formal proof of the expected negative relationship between the log of transit operating expenses and the log of transit vehicles is found in Williams (1979). He has demonstrated (p. 214) that, if the underlying production function is a Cobb-Douglas production function (as implicitly assumed by our cost equation 2), the \(a\ priori\) sign of the fleet size parameter in the cost function will be negative.

It may be possible to explain this negative relationship intuitively in the example of the transit company in at least two ways. First, if vehicles acquired in expanding the fleet are newer, maintenance cost may be reduced while a constant level of transit service is maintained if the newer vehicles are put into service and the older vehicles taken out of service and reserved for special need. Cost of maintaining the newer vehicles will be lower than the former cost of maintaining the older vehicles, especially if they are under warranty. Cost of maintaining vehicles kept in reserve will be lower than when the same vehicles were active. Thus, the total cost of maintaining a larger fleet consisting of newer vehicles in active service and older vehicles in inactive service may be lower than the cost of maintaining a smaller fleet consisting entirely of older vehicles in active service. Admittedly, this would be a short-run effect, and could not be sustained if the average age of the vehicles in active service returned to its original equilibrium level.

Second, a larger fleet providing the same level of transit service would permit more flexible scheduling of maintenance down-time. Thus, if there are more inactive vehicles available as temporary substitutes for an active vehicle which requires maintenance, it may be possible to schedule the maintenance during mechanics' normal working hours, instead of during overtime pay hours.

Obviously, the \(a\ priori\) sign of \(a_4\) can be positive; that is, an increase in miles
of dial-a-ride service provided by taxicab companies under contract to the TTDC, if the service-miles of other services remain constant, would increase the operating expenses of the TTDC. This follows, since the TTDC pays the taxicab companies a specified fee for each hour of service provided. However, on the basis of our previous discussion of the impact of this contracted-out service on TTDC's cost structure, it also follows that the sign can be negative. This hypothesis that an increase in service (or output) of a firm will result in lower costs for the firm is strange, to say the least. It does not appear to be a possibility for a single service firm, but the possibility does exist for a multiservice firm.

Whether the a priori sign of $a_4$ will be negative or positive will depend on whether the indirect effect on the TTDC's operating expenses of increased shared-ride taxi service outweighs its direct effect. The indirect effect is the lowering of the cost of motorbus service (as previously explained); the direct effect is the increased cost directly attributable to shared-ride taxi service. If the former is greater in absolute magnitude than the latter, the a priori sign of $a_4$ will be negative; otherwise, it will be positive.

V. DATA

Data for estimation of equation (2) were obtained from the financial records of the TTDC. Since all four services were in operation only from September 1979, our data set consists of quarterly observations from September 1979 to August 1984; that is, a time series sample of 20 observations.

There is no perfect output measurement of the service provided by a transit firm, but the empirical literature generally considers vehicle-miles of service as a measure of output. In addition, in some cases, the number of passengers transported has been used. In a paper by Berechman and Giuliano (1984, p. 274), vehicle-miles and passenger-trips are referred to as technical and demand-related measures of output; technical output measures relate to changes in capacity, and demand-related measures relate to changes in the utilisation of capacity. For the estimation of equation (2), we used vehicle-miles of service provided by each of the four services over the time period. However, passenger data were also substituted for the vehicle-mile data and equation (2) was re-estimated (as will be explained in the next section).

Observations for the price variables $P_l$ and $P_f$ are constructed price series. The price of labour ($P_l$) observations in the data set are weighted arithmetic mean prices. Specifically, the price of labour observation for a given quarter is a weighted hourly wage rate: where the hourly wage rates of various categories of TTDC employees such as operators, maintenance employees, supervisors, and other management employees for that quarter are weighted with the number of employees in each category. Similarly, the observations on price of fuel are weighted arithmetic mean prices: the prices of diesel and gasoline fuels per gallon incurred by the TTDC in a given quarter are weighted with the number of gallons of each type of fuel consumed in that quarter.

The short-run variable cost observations are the actual operating expenses incurred by the TTDC for each given quarter. The observations for the vehicle variables ($V_t$ and $V_o$) are the same as in the previous discussion.
VI. EMPIRICAL RESULTS

The estimation of equation (2) using the above sample is found in Table 2, as empirical equation 2-1. Coefficient estimates are presented, with the corresponding $t$-statistics placed below the coefficients in parentheses. Equation 2-1 according to the $F$ statistic is significant at the 5 per cent level, with variables $Q_{dm}$ and $P_f$ significant at the 5 per cent level and variable $P_i$ significant at the 1 per cent level. According to the Durbin-Watson statistic, positive serial correlation is unlikely.

The signs of the estimated coefficients agree with their a priori signs, with the possible exception of the negative sign on the $Q_{dm}$ coefficient. If this sign is correct, the implication, as previously explained, is that the indirect effect of cost savings to the TTDC in the provision of contracted-out dial-a-ride paratransit service outweighs the direct effect of increased cost to the TTDC in the provision of the service. The interpretation of the $Q_{dm}$ coefficient of $-0.1526$ is that a 10 per cent increase in contracted-out dial-a-ride paratransit service is expected to result in a 1.5 per cent decrease in the operating expenses of the TTDC, if the values of the remaining explanatory variables in the equation remain fixed. The implication of this result may be considered by some to be profound. Specifically, a transit firm can use contracted-out dial-a-ride paratransit service as a means of improving its cost efficiency by reducing the pay of transit operators for overtime and non-inservice time. Hence, a major conclusion of this paper is as follows. Contracted-out dial-a-ride paratransit service, used as it has been by the TTDC management, may induce unionised motorbus operators, fearful of job losses from the replacement service, to concede work-rule changes that allow transit management to change their work schedules in order to lower the cost of motorbus service.

The impact on the cost efficiency of motorbus service from work rule concessions motivated by contracted-out dial-a-ride service is also to some extent depicted in the coefficient on the log $Q_{tm}$. Specifically, the cost elasticity of 0.2558 for motorbus service (the coefficient on the log $Q_{tm}$) is lower than that found in several other studies. Williams (1979, p. 215), using a cross-section of 87 US motorbus transit firms, estimated a short-run variable cost function and obtained a cost elasticity of 0.469. Similarly, Viton (1981a, p. 296), in estimating a short-run variable cost function from a cross-section of 54 US motorbus transit firms, found cost elasticities of 0.51, 0.56, and 0.60 for motorbus service. However, new transit service can be provided by the TTDC at lower cost because less costly regular-time hours are substituted for overtime pay hours. The lower cost elasticity of 0.2558 also reflects the use of a small number of minibuses on some transit routes, where the operators receive a non-union wage rate (and thus a lower wage rate than the union rate) and no compensation for non-inservice time. The cost elasticity of 0.2558 indicates that a 10 per cent increase in motorbus service is expected to result in approximately a 2.5 per cent increase in the operating expenses of the TTDC.

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10 For other cost-function estimates of single-service transit firms providing motorbus service, see Berechman (1983), De Borger (1984), Wabe and Coles (1975), and Wilson (1977).
## TABLE 2

**Short-Run Variable Cost Equation Estimations**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Equation 2-1</th>
<th>Equation 2-2</th>
<th>Equation 2-3</th>
<th>Equation 2-4</th>
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<tr>
<td>$Q_{tm}$</td>
<td>0.2558</td>
<td>0.2600</td>
<td>0.3452</td>
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<td></td>
<td>(0.9670)</td>
<td>(0.9304)</td>
<td>(1.248)</td>
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<td>$Q_{ebm}$</td>
<td>0.2420</td>
<td>0.1782</td>
<td>0.2867</td>
<td></td>
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<tr>
<td></td>
<td>(0.9067)</td>
<td>(0.6584)</td>
<td>(0.9268)</td>
<td></td>
</tr>
<tr>
<td>$Q_{em}$</td>
<td>0.1759</td>
<td>0.1459</td>
<td>0.1101</td>
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</tr>
<tr>
<td></td>
<td>(0.8208)</td>
<td>(0.6557)</td>
<td>(0.4777)</td>
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<tr>
<td>$Q_{dm}$</td>
<td>-0.1526*</td>
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<td>(-2.663)</td>
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<td>$Q_{sp}$</td>
<td></td>
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<td></td>
<td></td>
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<td>$Q_{sdp}$</td>
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<td>(1.726)</td>
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<td>$Q_{tp}$</td>
<td></td>
<td>0.0304</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(0.3478)</td>
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<td></td>
</tr>
<tr>
<td>$Q_{dp}$</td>
<td></td>
<td>-0.0952*</td>
<td>-0.0964*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-2.400)</td>
<td>(-2.381)</td>
<td></td>
</tr>
<tr>
<td>$Q_{db}$</td>
<td></td>
<td></td>
<td></td>
<td>-0.1089*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-2.124)</td>
</tr>
<tr>
<td>$P_{t}$</td>
<td>3.079†</td>
<td>2.619†</td>
<td>2.718*</td>
<td>2.971*</td>
</tr>
<tr>
<td></td>
<td>(3.049)</td>
<td>(3.533)</td>
<td>(2.749)</td>
<td>(2.618)</td>
</tr>
<tr>
<td>$P_{f}$</td>
<td>0.7606*</td>
<td>0.8429*</td>
<td>0.5145</td>
<td>0.5716</td>
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<tr>
<td></td>
<td>(2.117)</td>
<td>(2.584)</td>
<td>(1.574)</td>
<td>(1.593)</td>
</tr>
<tr>
<td>$V_{t}$</td>
<td>-1.212</td>
<td>-1.513</td>
<td>-1.047</td>
<td>-1.535</td>
</tr>
<tr>
<td></td>
<td>(-1.570)</td>
<td>(-1.683)</td>
<td>(-1.314)</td>
<td>(-1.749)</td>
</tr>
<tr>
<td>$V_{o}$</td>
<td>-0.3428</td>
<td>-0.2110</td>
<td>-0.2948</td>
<td>-0.3848</td>
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<td>(-1.251)</td>
<td>(-0.9553)</td>
<td>(-1.049)</td>
<td>(-1.235)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.767</td>
<td>8.695</td>
<td>1.875</td>
<td>2.089</td>
</tr>
<tr>
<td></td>
<td>(0.3400)</td>
<td>(2.594)</td>
<td>(0.3462)</td>
<td>(0.3713)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.7206</td>
<td>0.6938</td>
<td>0.6967</td>
<td>0.6741</td>
</tr>
<tr>
<td>$DW$</td>
<td>2.6679</td>
<td>2.8818</td>
<td>2.6715</td>
<td>2.6533</td>
</tr>
<tr>
<td>$F$</td>
<td>3.546</td>
<td>3.116</td>
<td>3.159</td>
<td>2.844</td>
</tr>
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</table>

* Significant at the 5 per cent level.
† Significant at the 1 per cent level.
Since, as stated previously, the coefficients of equation 2-1 in Table 2 are interpreted as partial cost elasticities, these coefficients can be compared to indicate the relative impact on the TTDC's operating expenses from a given percentage increase in each explanatory variable. Specifically, in a comparison involving the vehicle-mile variables, it follows that it is relatively more expensive to increase motorbus service than to increase any one of the paratransit services. This is expected because the level of transit output is higher than the levels of the other services, and the marginal cost of transit service is also relatively high. However, the partial cost elasticity of service for the elderly and handicapped (0.2420) is only slightly lower than that of transit service, while its level is much lower; thus, its marginal cost may be higher. For the paratransit services, service for the elderly and handicapped is relatively more expensive to increase than van pool and dial-a-ride services, and van pool service is relatively more expensive to increase than dial-a-ride service. In the ranking of the coefficients of the shift parameters in equation 2-1 with respect to their absolute magnitudes, it follows that the cost elasticity with respect to the price of labour is the largest; the cost elasticity with respect to the number of buses is second; and the cost elasticity with respect to the price of fuel is third in magnitude. The first ranking of the price of labour was to be expected, since labour cost is the main component of the operating expenses of a motorbus transit firm. The high ranking of the price of fuel was also to be expected, since fuel costs as a percentage of transit operating expenses have increased to a significant level in recent years as a result of rising fuel prices.

In order to provide further support for the existence of the negative relationship between the TTDC's operating expenses and contracted-out dial-a-ride service, equation (2) was re-estimated by substituting the number of passengers \( Q_p \) carried for the vehicle-miles of each service. The estimation appears as equation 2-2 in Table 2. As was found previously, there is a negative relationship between the TTDC's operating expenses and contracted-out dial-a-ride service (now measured by the number of passengers carried). However, the relative magnitudes of the cost elasticities of the services with respect to passengers carried differ from those with respect to vehicle-miles. For a given percentage increase in passengers carried, service for the elderly and handicapped is relatively more expensive now than motorbus service. As before, van pool and dial-a-ride services are relatively less expensive for a given percentage increase in passengers carried than either motorbus or elderly and handicapped service. Furthermore, the absolute magnitude of the cost elasticities of the services with respect to passengers carried are correspondingly less than those with respect to vehicle-miles. A similar finding for motorbus service was made by Berechman and Giuliano (1984, p. 283).

In addition to these two estimates, two additional estimates were made. Motorbus, elderly and handicapped, and van pool services were measured in vehicle-miles, and dial-a-ride service was measured in number of passengers carried (the remaining variables being the same as in the first two cost-function estimates). This estimate appears as equation 2-3 in Table 2. The sign on the log \( Q_d p \) is negative, so the estimate again supports the negative relationship between the TTDC's operating expenses and contracted-out dial-a-ride service.
A MULTISERVICE TRANSIT FIRM

For the next estimate, hours \( Q_{db} \) of dial-a-ride service provided were substituted for the number of dial-a-ride passengers carried. This estimate appears as equation 2-4 in Table 2. It again supports the negative relationship between TTDC's operating expenses and contracted-out dial-a-ride service.

VII. CONCLUSIONS

As far as the authors are aware, this paper is the first to appear that presents an empirical cost analysis of a multiservice transit firm, providing both transit and paratransit services. It is also the first paper to present an empirical cost analysis of a transit firm that contracts out a service to a private provider such as a taxicab company. A number of conclusions follow from the analysis. First, contracting out a replacement service may induce unionised motorbus operators fearful of job losses to concede work-rule changes that allow transit management to change their work schedules in order to lower the cost of motorbus service. By a restructuring of work schedules, overtime hours (and hence overtime and more expensive pay) can be reduced. Also, with the threat of further contracting out of service, the transit firm is in a position to obtain work-rule concessions from unionised operators such as, for example, reductions in non-in-service time for which they receive compensation, but for which no service is performed. This conclusion is supported by the negative relationship found between TTDC's cost and the level of the contracted-out service, as well as by the fact that the cost elasticity for motorbus service was lower than that found in previous studies.

Second, with service provision measured in terms of vehicle-miles, the order of TTDC's services, ranked according from those having the largest cost elasticity to the smallest, is: motorbus, elderly and handicapped paratransit, van pool paratransit, and contracted-out dial-a-ride paratransit service. Thus it is relatively more expensive to increase motorbus service (measured in vehicle miles) than to increase any one of the paratransit services. Third, however, with service provision measured in terms of passengers transported, the order of TTDC's services ranked according from the largest cost elasticity to the smallest becomes: elderly and handicapped paratransit, motorbus, van pool paratransit, and dial-a-ride paratransit service. Thus it is relatively more expensive to increase paratransit service for the elderly and handicapped (measured in number of passengers transported) than to increase motorbus service. Fourth, as expected, TTDC's cost elasticities with the largest absolute magnitudes are those with respect to the price of labour, number of buses, and price of fuel.

With operating subsidies to public transit firms likely to decline, these firms will be under pressure to consider alternative methods (other than increasing fares or reducing transit service) of reducing their operating deficits. The results of this paper indicate that a restructuring of the transit firm as a paratransit-transit firm that contracts out service is a viable alternative. This follows since such a firm attacks the underlying problem of transit operating deficits (that is, escalating costs). Furthermore, the lower costs incurred by such a firm may be achieved without loss of jobs of transit operators.
APPENDIX

Memoranda of Agreements Between the TTDC and the Amalgamated Transit Union

I. 1979–1982 Agreement

A. Workweek-workday provisions
1. All regular runs, minimum of 8 hours per day.
2. The minimum regular weekly run shall be 40 hours.
3. Time and one-half the regular rate of pay for all time worked in excess of regular scheduled board runs.

B. Operator wage rates
1. Hourly rates of pay for operators hired on or after 1 October 1977 but before 1 January 1980: first six months, 80% of top rate; second six months, 85% of top rate; third six months, 90% of top rate; fourth 6 months, 95% of top rate; and after 2 years, 100% of top rate.
2. Hourly rates of pay for operators hired on or after 1 January 1980: first year, 70% of top rate; second year, 80% of top rate; third year, 90% of top rate; and after 3 years, 100% of top rate.

II. 1982–1983 Agreement

A. Workweek-workday provisions
1. All regular runs, minimum of 7.5 hours per day.
2. The minimum regular weekly run time shall be 40 hours.
3. Time and one-half the regular rate of pay for all time worked in excess of regular scheduled board runs.

B. Operator wage rates
1. Hourly rates of pay for operators hired on or after 1 January 1980: first year, 70% of top rate; second year, 80% of top rate; third year, 90% of top rate; and after 3 years, 100% of top rate.

C. Minibus service
1. The TTDC will establish a minibus operator position and a minibus division, which shall provide minibus service and shall be a part of the bargaining unit.
2. Minibus service shall include new dial-a-ride and small-bus service; such service provided as of 1 October 1982 shall remain outside the bargaining unit; also, van pool service and special transportation services for the elderly and handicapped are outside of the bargaining unit.
3. Minibus operators shall be classified as furloughed employees and/or new employees.
4. Furloughed employees are regular operators who have furloughed from the company's line service or wished to take a position as a minibus operator; furloughed employees shall receive all benefits given the regular operators except that they shall be entitled to only 2 paid holidays per year and one week's vacation and shall be paid at the rate of $5.32 per hour.
5. New hires are new employees hired to operate minibus service; they are entitled to only 2 paid holidays per year, 2 paid days for sick leave, and one week’s vacation and shall be paid at the rate of $4.00 per hour.
6. Both new hires and furloughed employees will be guaranteed 40 hours per week and shall be paid overtime at a rate of time and one-half.
7. No other work rules will apply to either furloughed or new minibus operators including, but not limited to spread time, pad time, report time, accident reporting time, intervening time, drop-back time for meals, travel time, turn-in time or any other work rule which applies to regular operators.
8. The company agrees that during the term of the agreement it shall limit the number of minibus operators to 20 positions.
9. Other than work converted to minibus service and other than the non-bargaining unit work, no line service now being operated by regular operators shall be leased or subcontracted out to any governmental unit, individual or corporation during the term of the agreement.

III. 1983–1986 Agreement

A. Workweek-workday provisions
1. Same as for the 1982–83 agreement above.

B. Operator wage rates
1. The top operator rate of pay shall be: $9.83 effective 1 November 1983 and $10.02 effective 1 April 1984.
2. The above rates of pay for all operators hired on or after 2 October 1983 shall be subject to the following wage progression: first year, 45% of top rate; second year, 50% of top rate; third year, 55% of top rate; fourth year, 60% of top rate, fifth year, 70% of top rate; sixth year, 80% of top rate; seventh year, 90% of top rate; and eighth year, 100% of top rate.

C. Exceptions to bargaining unit work
1. Bargaining unit work does not include van pool and special transportation services for the elderly and handicapped and all existing dial-a-ride and minibus services not being performed by bargaining unit employees on 1 May 1984.

D. Contracting
1. Notwithstanding the company’s agreement not to subcontract, the company may subcontract certain work being done by bargaining unit employees such as, for example, technological or innovative work not feasible to be done by bargaining unit employees and work which is necessary to be subcontracted because of an insufficient number of bargaining units.
2. Bargaining unit work which may not be subcontracted includes that service which provides bus service between two existing bargaining unit route points.
3. If new service shares a common route with existing bargaining unit work, then such new service that shares the common route shall be deemed work which cannot be subcontracted or which cannot be performed by non-bargaining unit employees.
4. It is specifically recognised and understood that the company may subcontract, fund, lease or operate future new non-bargaining unit work, notwithstanding its present intentions.
REFERENCES


