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# THE VALUE OF COMMERCIAL VEHICLE TIME SAVINGS FOR THE EVALUATION OF HIGHWAY INVESTMENTS: A RESOURCE SAVING APPROACH

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**ABSTRACT**

The value of travel time savings is the most important benefit category in nearly all highway cost-benefit studies. There is substantial literature on valuing time savings for auto drivers and transit users, but surprisingly few studies of the value of commercial vehicle time savings (VCVTS). There are various approaches to estimating VCVTS. We use a resource saving approach: categories and levels of various truck cost components are identified which vary with time. These resources produce output valued by consumers, i.e., time savings result in increased output which is expressed in consumer prices (gross of profit margins and taxes). These assumptions give a maximum value for VCVTS, i.e., the value of time savings (or delays) assuming resources affected can be reallocated by commercial vehicle owners. If companies cannot make any use of time savings, a minimum VCVTS is calculated. This is limited to personal time savings or delays to the driver, a fraction of the wage. These maximum and minimum VCVTS are calculated for a number of truck sizes and for some smaller vehicles. There is a substantial difference between the maximum and minimum VCVTS estimates. Road improvements generate ongoing or cumulative time savings; for this and other reasons we suggest that the VCVTS for road project evaluation should be something close to the maximum value calculated.

The largest benefit category in most cost benefit studies of road projects is the imputed value of travel time savings (VTTS). The majority of empirical studies of VTTS concentrate on auto drivers and, to a lesser extent, travellers on public transit. Surprisingly little work has focused on the VTTS for commercial vehicles, i.e., motor carriers. It is recognized, by definition, that commercial vehicle time savings are work time rather than non-work travel time, hence a higher VTTS is appropriate than for motorists who are commuting or engaged in leisure travel. Typically, the value of commercial vehicle time savings (VCVTS) is set equal to the drivers' wage including allowance for fringe benefits, with little further discussion of the figure adopted.

Large commercial vehicles (trucks) constitute a significant portion of total highway traffic -- often about 10 percent -- and their higher operating costs and value of time compared to automobiles make the VCVTS an important component of the benefits of highway improvements. This paper reviews alternate approaches to valuing time savings for commercial vehicles, and calculates a likely range of values for the VCVTS.

We first review the figures used for the VCVTS in various studies to evaluate highway investments in North America and in a few overseas countries. Next the paper identifies four approaches for estimating the VCVTS. Using a resource saving approach, estimates of truck costs in Canada and assumptions about the avoidability of various cost categories with respect to time savings are used to estimate a range of values for VCVTS in Canada. A separate survey was conducted for small commercial vehicles. A crucial assumption in studies of the value of time savings concerns the use of those time savings. Are time savings used productively, or are they merely incremental leisure time to drivers? For this paper we calculate the implied VCVTS under the two extreme assumptions: (1) assuming time saved cannot be used productively; and (2) assuming that time savings can be fully utilized. The last part of the paper argues that something close to the maximum VCVTS is appropriate for highway project evaluation.

## EXISTING VALUES FOR TIME SAVINGS OF COMMERCIAL VEHICLES

Table 1 lists the figures used for value of truck time for highway project evaluation in various jurisdictions. The figures are listed for different axle configurations but note that most

**Table 1: Values of Time Savings for Commercial Vehicles (1993 US$)**

| CAUTION: Figures for US sources were converted to $CDN and indexed up, then converted back to $US for this paper. Final figure could differ from US indexing procedure. | Number of Axles | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7+ |
| **United States** | | | | | | |
| AASHTO 1977 | 15.72 | 15.72 | 17.97 | 17.97 | 17.97 | 17.97 |
| Chui & McFarland (for new AASHTO) | 16.35 | 19.52 | 24.34 | 27.02 | 27.02 | 27.02 |
| HERS* | 23.37 | 26.71 | 29.69 | 29.86 | 29.86 | 29.86 |
| California* | 16.22 | 16.22 | 16.22 | 16.22 | 16.22 | 16.22 |
| Florida* | 13.63 | 13.63 | 17.01 | 17.01 | 17.01 | 18.89 |
| New York* | 15.78 | 15.78 | 15.78 | 15.78 | 15.78 | 15.78 |
| **Canada** | | | | | | |
| Alberta* | 19.86 | 19.86 | 19.86 | 19.86 | 19.86 | 19.86 |
| Quebec* | 11.92 | 11.92 | 12.87 | 12.87 | 12.87 | 12.87 |
| Ontario* | 31.60 | 31.60 | 31.60 | 31.60 | 31.60 | 31.60 |
| **Overseas** | | | | | | |
| Australian Road Research Board & New South Wales | 10.72 | 10.72 | 10.92 | 10.92 | 10.92 | 10.92 |
| Queensland | 11.00 | 11.00 | 12.06 | 12.06 | 12.06 | 12.06 |
| South Australia | 10.62 | 10.71 | 10.81 | 11.00 | 11.00 | 16.72 |
| New Zealand Road Project Evaluation Manual | 12.64 | 12.64 | 10.37 | 10.37 | 10.37 | 10.37 |
| Norway and Sweden | | | | | | |
| State Highways | 15.85 | 15.85 | 15.85 | 15.85 | 15.85 | 15.85 |
| Municipal Roads | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 |
| **Estimates From This Study** | | | | | | |
| Minimum VCVTS | 5.70 | → | → | 5.70 | → | 5.96 |
| Maximum VCVTS (general cargo) | 31.46 | → | → | 32.58 | → | 35.82 |

* Obtained by telephone interview, 1991-92.

agencies have VCVTS figures for only one or two categories of trucks.

Probably the most widely used figures are those of AASHTO (1977). This is the handbook for road project evaluation which has been most widely used in North America, at least until recently. AASHTO (1977) had only two categories of trucks, which we categorize as two or three axles and greater than three axles.[1] Expressed in 1993 US$ the figures are $15.72 and $17.97 per hour, respectively.[2] An update for AASHTO (1977) is underway as a National Cooperative Highway Research Project (NCHRP). The best indications of the values of truck time which will be included would be those of Chui and McFarland (1990). Their figures are US$16.35 to $27.02 per hour (1993$). Other U.S. figures are those of HERS (Highway Economic Requirements System) and figures for California, Florida and New York. These range from US$15.78 to US$27.51 depending on the size of truck and the agency.

Figures for three Canadian provinces are listed. The VCVTS for trucks in Quebec is in the US$12-$13 range. Alberta is US$19.86 for all trucks. Ontario was using a 1983 value of CDN$27.69, which we indexed up to US$31.60 in 1993$.

Table 1 also includes a few figures from overseas. New South Wales, Australia, uses two values for trucks in highway evaluation; the figure is just under US$11 per hour. South Australia uses US$10.62 to $16.72 (1993$). Norway and Sweden use US$10.18 per hour for rural roads and US$15.85 per hour on municipal (presumably reflecting a smaller average size vehicle in municipal areas).

The considerable range of values for the VCVTS may reflect different assumptions about what is included in VCVTS, e.g., does it include the value of cargo time or only the value of the driver's time, or driver plus vehicle? Broadly the VCVTS consists of three components: the value of time savings (or delays) for the driver, the vehicle, and the value of time savings to the cargo carried. The latter typically is much smaller than the direct costs associated with the driver and vehicle. This paper concentrates on the value of time savings for the transportation company and not the value of freight time.

## APPROACHES FOR ESTIMATING THE VALUE OF TIME SAVINGS FOR COMMERCIAL VEHICLES

The value of time savings (or time lost) can depend on circumstances of the journey as well as the type and size of the commercial vehicle. The key issue is whether the time savings merely provides spare (non-work) time for the driver or, results in greater production and/or reduction in transportation costs.

There are at least four approaches to estimating a VCVTS in the literature (see Wong, 1993 for a more extensive review):

1) cost savings method - this estimates the potential costs savings which can accrue to trucking companies due to time savings:[3]

2) revenue or net operating profit method - this values time savings in terms of the value of incremental output it is assumed can be produced from the resources freed by time savings;[4]

3) the implied value from previous government decisions - this method, labelled the "cost of time savings" method in the literature (Adkins, et al., 1967), infers a value of time from the costs associated with previous government decisions which affect travel time for trucks;

4) behavioral studies - these infer the value of time from situations in which motor carriers face time and monetary tradeoffs, or from questionnaire methods which pose time/monetary tradeoffs to drivers and/or carriers.

We comment on the latter two approaches first; the balance of the paper concentrates on the first two methods.

Inferring an implied value for commercial vehicle time savings from past government decisions is not a compelling approach. It begs the central question: what is the recommended VCVTS for government decision making? Given the multitude of factors which can influence any given decision, it is likely that a wide range of values would emerge, such as the wide range of values which emerge from examining the implied values of life from a number of different government safety decisions.

A variety of behavioral studies are possible, including both "revealed preference" studies (which infer the value form observed choices such as between toll and non-toll highways, or speed/operating cost tradeoffs) and "stated preference" methods (these utilize questionnaires which require drivers and/or carriers to indicate their preferences among various time and money tradeoffs). These approaches have been prominent in studies of values of time savings for passenger travel, but they are rare for commercial vehicles.

The major approaches used for valuing time savings of commercial vehicles are the cost savings approach and the revenue or net operating profit method. As will be seen, the two methods essentially are equivalent. Both are a "resource savings" approach, i.e. the value of time savings are defined in terms of resources (costs) saved.

**The Cost Savings Approach to VCVTS**

The cost savings method is exactly as the title suggests. Saving time makes it possible for carriers to supply the same output with lower total costs. The benefit or VCVTS is the difference in costs. This is illustrated in Figure 1. Assuming a competitive industry so the price received $P_1$ equals marginal costs $C_1$ of supplying the output, carriers are supplying $Q_1$ level of output. The benefit of time savings is the reduction in costs ($C_1$ - $C_2$) times $Q_1$. This is area ABCD in Figure 1. If the cost savings are passed on to customers as lower prices (as would be expected in a competitive industry), there would be some increased sales depending on the elasticity of demand. One would impute some benefit to this generated traffic (of 1/2 $\Delta C\ \Delta Q$), or area BCE in Figure 1 (however, in our calculations below we follow convention and do not incorporate the elasticity of demand).

Two caveats must be applied to the cost saving approach. Not all costs are related to time. Time savings enable only time-related costs to be saved, so it is necessary to estimate the proportion of total unit costs of commercial vehicles which are time-related. (There could be some change in non-time-related costs which accompany the time savings; if so the benefit measure must be net of any change in these other costs). The second qualification is the possibility that firms require time and incur some transactions costs to free up the resources released by time savings. This would reduce the effective benefits which can be realized by time savings. This is particularly relevant in distinguishing between short run and long run effects.

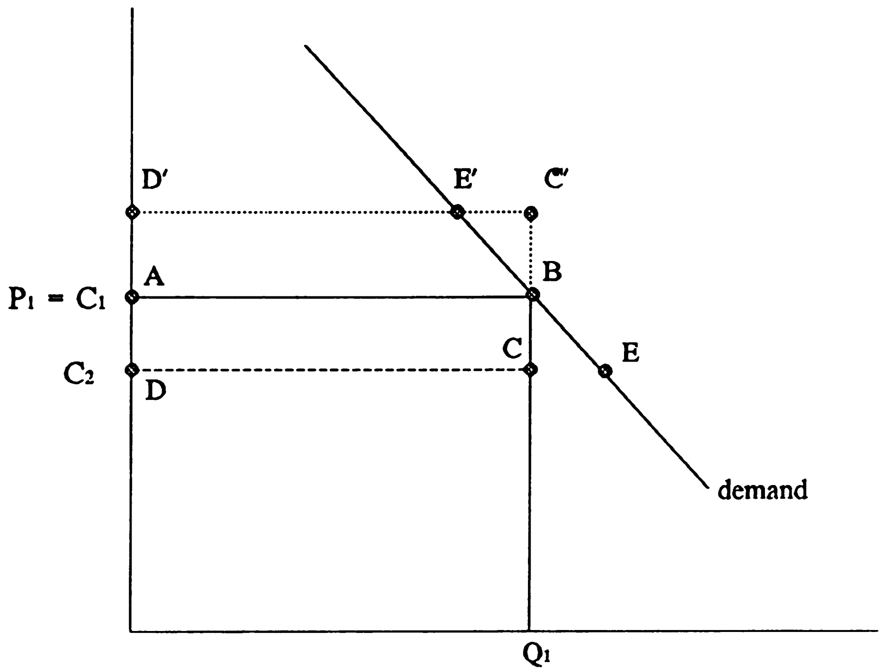
The opposite of time saving is time lost due to delays. Although the cost saving approach refers primarily to the benefits of saving travel time, the equivalent for time delays is to measure the additional costs firms must incur to offset losses of time. This would be illustrated by the upper rectangle in Figure 1: the quantity $Q_1$ times the change in costs. As pictured, we assume the costs necessary to offset a given delay are the same as the costs saved for an equivalent time savings. This is plausible in the long run, but they could differ substantially in the short run: the costs to offset delays could be higher in the short run than in the long run, while the opposite is probably true for costs saved due to time savings.

The cost increases due to delays would be reflected in an increased price to purchasers; therefore the rectangle ABC'D' in Figure 1 should be reduced by BC'E' in recognition of some elasticity of demand.

**The Revenue Method of Estimating VCVTS**

The "revenue method" of valuing time savings for commercial vehicles assumes that the resources freed up by time savings are used to supply additional output. Hence the benefit would be the incremental change in output times its price. Since it is only time-related costs which are reduced by time savings, an increase in output might entail some increase in non-time-related costs; if so, these must be deducted to arrive at the net value of increased output associated with the time saving. Calculating the quantity of output associated with an increment of time savings would be very difficult. In fact, the revenue approach does *not* calculate a selling price and increment of output. Instead, it calculates a reduction in costs similar to that in the cost-saving approach, and then assumes that an incremental amount of output is produced which is equal in value to the costs which could be saved by the time savings but instead are used to increase output. The two

**Figure 1**
**Cost Savings Method**
Cost savings associated with saving time
(or cost increases associated with delays)




methods would be identical except that the revenue method values the incremental output in consumer prices, i.e., gross of profit margins and sales taxes.

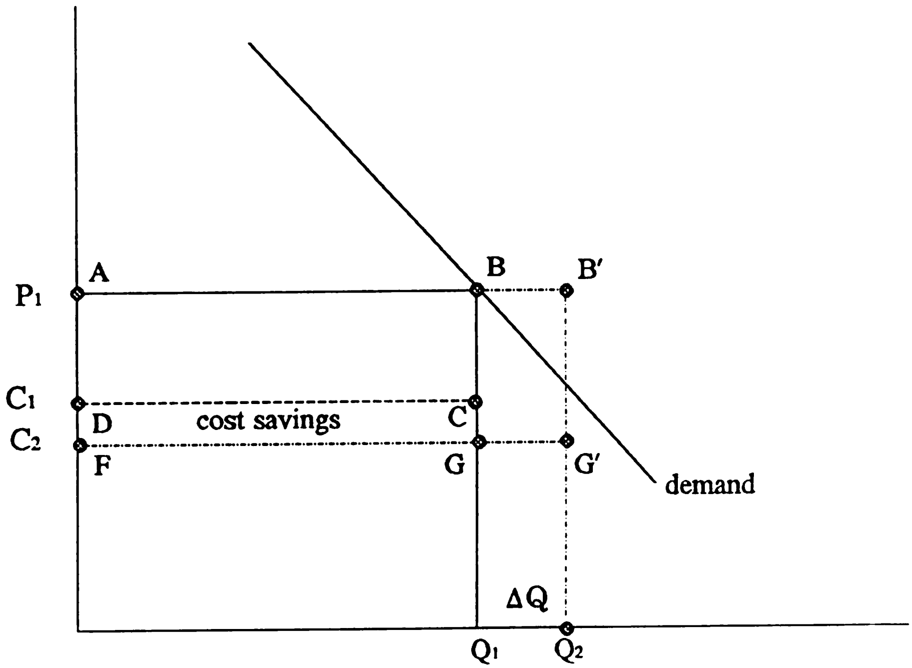
In Figure 2, the selling price $P_1$ is greater than costs $C_1$ by the amount of profit margins and sales taxes. A time saving reduces costs CDFG which is assumed to produce incremental output $Q_2$-$Q_1$ valued by consumers at price $P_1$ (CDFG = GG'$Q_2Q_1$). The value of the time savings is thus BB'$Q_2Q_1$ via the revenue method. The revenue method assumes that the market can readily absorb increases in output; this requires that demand be elastic.

Conversely, delays are assumed to cause lost output which are valued in terms of the prices being paid by customers. This is not illustrated in Figure 2 but delays would manifest themselves by output reductions valued at price $P_1$, i.e., the change in output BB' would be a leftward shift rather than the output increase shown in Figure 2.

**The Cost Savings Versus Revenue Approach for Valuing Time Savings**

In sum, the literature treats time savings differently depending on whether the cost savings or revenue approach is used. The cost savings approach literally calculates the cost reductions made possible by the time savings. In the revenue approach, the cost savings are assumed to result in incremental output which is valued in terms of consumer prices, i.e., inclusive of profit markups and any sales or excise tax (such as a national sales tax such as Canada's GST).[5] In the cost saving approach, "costs" are defined in terms of producer costs, i.e., the costs net of final markups and taxes. We think the revenue method is the correct approach for valuing long run time savings (or losses) for road project evaluation. Consider the profit markup first. A normal profit is considered an opportunity cost in economics. Resources have opportunity costs; only in the

**Figure 2**
**Revenue Method**
**(Cost savings result in additional output, valued in terms of selling price)**




short run might one omit an allowance for normal profit. This adjustment, and that for indirect taxes (e.g., a GST), is more apparent if we examine the cost saving approach more closely.

Consider the impact of time delays using the cost saving approach. In order to offset the impact of time delays, resources must be acquired to prevent loss of output and/or deterioration of service. These inputs have opportunity costs. They would earn a normal profit elsewhere in the economy. Further, resources employed elsewhere produce outputs which include a GST (and other sales taxes) in the price to consumers. The social opportunity costs of diverting resources from elsewhere in the economy is appropriately measured in terms of consumers' prices, i.e., resources should be "shadow-priced" to include the effect of taxation on the prices (hence the value of marginal outputs) faced by consumers.[6]

Conversely, for time savings which release resources to be used elsewhere in society, the incremental value of production they can produce elsewhere in the economy would be measured in consumers' prices, i.e., inclusive of normal profits and indirect taxes.

Hence, principles of social cost benefit analysis indicate that proper measurement of time savings method would shadow-price the resources saved in terms of the marginal value of the output the resources could produce elsewhere, this is in consumer prices, i.e., gross of tax. This is how the revenue method calculates the benefits (or costs) of time savings (delays). This is the method adopted below for calculating a maximum value for VCVTS.

## THE MINIMUM VALUE FOR COMMERCIAL VEHICLE TIME SAVINGS

By making pessimistic assumptions possible about how efficiently time savings can be utilized, a minimum value for VCVTS can be estimated. The most pessimistic assumption about the utilization of time savings is that carriers cannot utilize any of it. A highway improvement may decrease the travel time of a truck, but the carrier may not be able to force the driver to finish the route any earlier than before. In this case, the entire benefits from the travel time savings will accrue to the driver. The driver will have more leisure time which could be used to take longer breaks, leave work early, or start work late.

With these assumptions in place, the minimum value of time may then be thought of as the driver's value of leisure time. There have been numerous studies of VTTS for road users (e.g. MVA Consultancy, et al., 1987; Lawson, 1989; Miller, 1989, Waters, 1992). Various figures have been suggested as an approximate VTTS for non-work time, typically between 25 to 60 percent of the average wage (Waters, 1993). For these calculations we adopt 40 percent of the wage as the average VTTS for non-work time.

**Calculation of the Minimum Value of Commercial Vehicle Time Savings**

In Table 2, line (1) gives the percentage of several types of heavy commercial vehicles on British Columbia (B.C.) highways. These are from Statistics Canada's "Trucking in Canada" report for 1988.

Non-work time savings are valued relative to a wage. The minimum value of commercial vehicle time or value of "leisure time" (25) of the occupants of the commercial vehicle, was calculated by multiplying the hourly wage rate (14) by 40 percent.

The minimum VCVTS varies from $4.81 to $5.96 per hour depending on truck size (1993 $US).

In Table 3, similar figures are developed for two categories of light commercial vehicles (pickups or cargo vans and light trucks). These figures are based on a small survey so these figures should be regarded as provisional. The figures for minimum value of time are $4.90 and $6.47 per hour, the difference explained by different average wage levels for the two vehicle types.

## THE MAXIMUM VALUE OF COMMERCIAL VEHICLE TIME SAVINGS

**Cost Savings and the Value of Commercial Vehicle Time Savings**

As reported above, the so-called revenue method is adopted for valuing time savings. This is estimated by calculating the costs which can be saved due to time savings and expressing this in terms of consumer prices by adjusting for normal profits and taxation. Costs which may be saved as a result of travel time savings include driver's and helper's wages and their wage burden (overhead), vehicle ownership and operating costs, plus carriers' profits and sales taxes (to express in consumer prices). See Table 2.

Although it may be easy to see how wages paid to employees vary with the hours of operation, it may be more difficult to see how vehicle ownership costs vary with the hours of operation.

In the short-run, vehicle ownership costs are fixed. But in the long-run, some short run fixed costs become variable. Travel time savings mean that fewer vehicles will be required to transport a given quantity of goods a given distance. Fewer vehicles required will mean that the fixed costs associated with those vehicles will no longer have to be incurred. The time savings will enable costs which vary with the number of vehicles to be saved. These costs include time-related maintenance costs, time-related depreciation costs, the opportunity (interest) cost of the money tied up in the vehicle, licensing fees and time-related insurance costs. The latter are a function of distance travelled; using reported insurance figures for trucks travelling different distances, we imputed the implied "fixed charge" embodied in insurance costs and assigned this fixed component to be time-related (it ranges from 10 to 25 percent of total insurance costs).

If only a few minutes of time are saved, there may be indivisibilities which limit the ability to save the fixed costs associated with owning a vehicle. This is an ongoing issue in valuing time savings both for non-work as well as work travel. Empirical evidence on the value of small time savings is rare. Various arguments have been put forth. First, note that highway improvements generate permanent time savings which can be worked into transport

**Table 2. Summary Value of Commercial Vehicle Time Savings: Heavy Vehicles**

| | all dollar figures in 1993 US $ (converted from CDN $) | | trailer | (Bulk Commodity) 2-axle gasoline | 2-axle diesel | 5-axle diesel | 7-8 axle diesel | (General/Dry Freight) 2-axle gasoline | 2-axle diesel | 5-axle diesel | 7-8 axle diesel |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % on road (1988) | | | 5.80% | 6.50% | 15.90% | 1.80% | 13.50% | 15.20% | 37.20% | 4.10% |
| | **General Assumptions** | | | | | | | | | | |
| a) | Average cost of new truck/tractor | | | $75,140 | $80,117 | $97,980 | $98,314 | $43,250 | $48,227 | $97,980 | $98,314 |
| b) | Average cost of new trailer | | | --- | --- | $46,805 | $89,627 | --- | --- | $30,574 | $35,085 |
| c) | Annual repair cost of truck/tractor | | | $3,350 | $3,997 | $10,642 | $11,018 | $3,350 | $3,997 | $10,642 | $11,018 |
| d) | Annual repair cost of trailer | | | --- | --- | $4,981 | $6,189 | --- | --- | $4,528 | $4,981 |
| e) | Annual truck/tractor licence fee | | | $396 | $396 | $1,404 | $2,341 | $396 | $396 | $1,404 | $2,341 |
| f) | Annual trailer licence fee | | | --- | --- | $21 | $42 | --- | --- | $21 | $42 |
| g) | Annual Insurance cost truck/tractor & trailer | | | $3,393 | $3,154 | $5,930 | $7,015 | $5,456 | $5,248 | $6,523 | $7,896 |
| h) | Average age of vehicle (years) | | 4 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| i) | Depreciation per year | | 12% | 16% | 16% | 16% | 16% | 16% | 16% | 16% | 16% |
| j) | Depreciation due to time | | 20% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% |
| k) | Repair/maintenance due to time | | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| l) | Cost of money | | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% |
| m) | Insurance cost due to time | | | 15% | 18% | 19% | 20% | 5% | 6% | 16% | 14% |
| n) | Assumed annual hours | | | 2,400 | 2,400 | 3,000 | 3,000 | 2,400 | 2,400 | 3,000 | 3,000 |
| | **Cost of Ownership** | | | | | | | | | | |
| | **Truck/Tractor:** | | | | | | | | | | |
| 1) | Hourly repair cost | ( c x k ) / n | | $0.28 | $0.33 | $0.71 | $0.73 | $0.28 | $0.33 | $0.71 | $0.73 |
| 2) | Hourly depreciation cost | ( a x i x j ) / n | | $2.00 | $2.14 | $2.09 | $2.10 | $1.15 | $1.29 | $2.09 | $2.10 |
| 3) | Hourly interest cost | ( a - [ a x h x i ] ) l / n | | $2.25 | $2.40 | $2.35 | $2.36 | $1.30 | $1.45 | $2.35 | $2.36 |
| 4) | Hourly licence cost | ( e / n ) | | $0.17 | $0.17 | $0.47 | $0.78 | $0.17 | $0.17 | $0.47 | $0.78 |
| | **Trailer:** | | | | | | | | | | |
| 5) | Hourly repair cost | ( d x k ) / n | | --- | --- | $0.33 | $0.41 | --- | --- | $0.30 | $0.33 |
| 6) | Hourly depreciation cost | ( b x i x j )/ n | | --- | --- | $0.37 | $0.72 | --- | --- | $0.24 | $0.28 |
| 7) | Hourly interest cost | ( b - [ b x h x i ] ) l / n | | --- | --- | $0.97 | $1.86 | --- | --- | $0.64 | $0.73 |
| 8) | Hourly licence cost | ( f / n ) | | --- | --- | $0.01 | $0.01 | --- | --- | $0.01 | $0.01 |
| 9) | Hourly insur. cost, truck/tractor & trailer | ( g x m ) / n | | $0.21 | $0.24 | $0.38 | $0.47 | $0.11 | $0.13 | $0.35 | $0.37 |
| 10) | Hourly cost of ownership | Σ of 1...9 | | $4.91 | $5.28 | $7.68 | $9.44 | $3.01 | $3.37 | $7.16 | $7.69 |

**Table 2. Summary Value of Commercial Vehicle Time Savings: Heavy Vehicles**

| | all dollar figures in 1993 US $ (converted from CDN $) | (Bulk Commodity) | | | | (General/Dry Freight) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | trailer | 2-axle gasoline | 2-axle diesel | 5-axle diesel | 7-8 axle diesel | 2-axle gasoline | 2-axle diesel | 5-axle diesel | 7-8 axle diesel |
| 11) Profit markup (5%) | ( 10 x 5%) | $0.25 | $0.26 | $0.38 | $0.47 | $0.15 | $0.17 | $0.36 | $0.38 |
| 12) GST + PST (7% each) | ( 10 + 11) x 14% | $0.72 | $0.78 | $1.13 | $1.39 | $0.44 | $0.50 | $1.05 | $1.13 |
| 13) **Hourly value of vehicle time** | ( 10 + 11 + 12 ) | $5.88 | $6.32 | $9.19 | $11.30 | $3.60 | $4.04 | $8.57 | $9.20 |
| **Cost of Driver** | | | | | | | | | |
| 14) Driver's hourly wage | | 12.03 | 12.03 | 12.03 | 12.13 | 14.25 | 14.25 | 14.25 | 14.91 |
| 15) Driver's wage burden | | 26% | 26% | 28% | 30% | 53% | 53% | 34% | 42% |
| 16) Driver's hourly wage burden | ( 14 x 15 ) | 3.13 | 3.13 | 3.37 | 3.64 | 7.55 | 7.55 | 4.85 | 6.26 |
| 17) Hourly cost of driver | ( 14 + 16 ) | $15.16 | $15.16 | $15.40 | $15.77 | $21.81 | $21.81 | $19.10 | $21.18 |
| 18) Hourly cost of helper | ( 17 x 50% x 10% ) | $0.76 | $0.76 | $0.77 | $0.79 | $1.09 | $1.09 | $0.96 | $1.06 |
| 19) Profit markup (5%) | ( 17 + 18 ) x 5% | $0.80 | $0.80 | $0.81 | $0.83 | $1.15 | $1.15 | $1.00 | $1.11 |
| 20) GST + PST (7% each) | ( 17 + 18 + 19 ) x 14% | $2.34 | $2.34 | $2.38 | $2.43 | $3.37 | $3.37 | $2.95 | $3.27 |
| 21) **Hourly value of driver time** | ( 17 + 18 + 19 + 20 ) | $19.06 | $19.06 | $19.36 | $19.82 | $27.42 | $27.42 | $24.01 | $26.62 |
| **Value of Time Savings** | | | | | | | | | |
| 22) Hourly value of vehicle time | ( 13 ) | $5.88 | $6.32 | $9.19 | $11.30 | $3.60 | $4.04 | $8.57 | $9.20 |
| 23) Hourly value of driver time | ( 21 ) | $19.06 | $19.06 | $19.36 | $19.82 | $27.42 | $27.42 | $24.01 | $26.62 |
| 24) Maximum value of time savings | ( 22 + 23 ) | $24.94 | $25.38 | $28.55 | $31.12 | $31.02 | $31.46 | $32.58 | $35.82 |
| 25) Minimum value of time savings * | ( 14 x 40%) | $4.81 | $4.81 | $4.81 | $4.85 | $5.70 | $5.70 | $5.70 | $5.96 |

* 40% of wages (net of fringes and benefits)

**Table 3. Calculation of VCVTS for Small Commercial Vehicles**

| | all dollar figures in 1993 US $ (converted from CDN $) | | pickups and cargo vans | light trucks |
|---|---|---|---|---|
| | Number of vehicles surveyed | | 3169 | 422 |
| | **General Assumptions** | | | |
| a) | Average cost of new vehicle | | $21,899 | $51,268 |
| b) | Estimated salvage value | | $10,893 | $26,968 |
| c) | Average service life (years) | | 11.5 | 9.9 |
| d) | Average vehicle age (years) | | 6.5 | 4.0 |
| e) | Depreciation due to time | | 30% | 30% |
| f) | Repair/maintenance due to time | | 20% | 20% |
| g) | License/insurance due to time | | 25% | 25% |
| h) | Assumed annual hours | | 2,400 | 3,000 |
| i) | Average annual distance (km) | | 18,135 | 124,867 |
| | **Cost of Ownership** | | | |
| 1) | Cost of repairs annually | | $1,772.57 | $1,967.87 |
| 2) | Repairs related to time | ( 1 x f ) | $354.51 | $393.57 |
| 3) | **Hourly repair cost** | ( 2 / h ) | **$0.15** | **$0.13** |
| 4) | Capital cost | ( a ) | $21,898.74 | $51,268.41 |
| 5) | Annual depreciation | ( a - b ) / c | $957.01 | $2,454.61 |
| 6) | Depreciation due to time | ( 5 x e ) | $287.10 | $736.38 |
| 7) | **Hourly depreciation cost** | ( 6 / h ) | **$0.12** | **$0.25** |
| 8) | Current capital value | ( a - [ d x 5 ]) | $15,678.20 | $41,449.96 |
| 9) | Annual value of interest (12%) | ( 8 x 12% ) | $1,881.38 | $4,974.00 |
| 10) | **Hourly interest cost** | ( 9 / h ) | **$0.78** | **$1.66** |
| 11) | Annual license and insurance fees | | $919.23 | $2,361.87 |
| 12) | **Hourly license/insurance** | ( 11 x g ) / h | **$0.10** | **$0.20** |
| 13) | ***Hourly cost of ownership*** | ( 3 + 7 + 10 + 12 ) | **$1.15** | **$2.23** |
| 14) | Profit markup (5%) | ( 13 x 5%) | $0.06 | $0.11 |
| 15) | GST + PST (7% each) | ( 13 + 14 ) x 14% | $0.17 | $0.33 |
| 16) | ***Hourly value of vehicle time*** | ( 13 + 14 + 15 ) | **$1.38** | **$2.67** |
| | **Cost of Driver** | | | |
| 17) | Driver's hourly wage | | $12.25 | $16.18 |
| 18) | Driver's wage burden | | 28% | 29% |
| 19) | Driver's hourly wage burden | ( 17 x 18 ) | $3.43 | $4.69 |
| 20) | ***Hourly cost of driver*** | ( 17 + 19 ) | $15.68 | $20.87 |
| 21) | Profit markup (5%) | ( 20 x 5%) | $0.78 | $1.04 |
| 22) | GST + PST (7% each) | ( 20 + 21 ) x 14% | $2.30 | $3.07 |
| 23) | ***Hourly value of driver time*** | ( 20 + 21 + 22 ) | **$18.77** | **$24.99** |
| | **Value of Time Savings** | | | |
| 24) | Hourly value of vehicle time | ( 16 ) | $1.38 | $2.67 |
| 25) | Hourly value of driver time | ( 23 ) | $18.77 | $24.99 |
| 26) | Maximum value of time savings | ( 24 + 25 ) | **$20.15** | **$27.66** |
| 27) | Minimum value of time savings * | ( 17 x 40% ) | $4.90 | $6.47 |

* 40% of wages (net of fringes and benefits)

operations.[7] Second, it may be that many vehicles do not value small time savings; but using an average value of time may still be reasonable. Suppose many trucks could not utilize small time savings, but for a few, the small time savings supplement other small time savings and reach a threshold amount of time saved to enable substantial savings. Thus a few vehicles value time savings very highly while most would not; in this case an average value of time applied to all vehicles could still be a reasonable approximation. (This is a variation on an argument by Harrison and Quarmby, 1969). Finally, note that time savings from highway investments are cumulative. Roads are upgraded over time, curves straightened, grades reduced, etc. The cumulative result of many improvements can be a substantial change in trip times, but these improvements would not come about if one did not assume that small time savings were valuable. Therefore we continue the practice of valuing small time savings, i.e., we adopt a long run perspective in calculating a maximum value for commercial vehicle time savings, and thus assume that indivisibilities do not affect the efficiency with which carriers can utilize time savings. That is, we calculate a maximum value for VCVTS.

Since we are valuing incremental truck output due to freed resources -- hence truck time -- at consumer prices, normal profit margin plus any taxes added on to the price of trucking services must be included in the value of time. Taxes here refer to taxes levied on sales to consumers. Transportation is an intermediate good, but transport costs become embodied in the final selling price of goods, and taxes are imposed on these embodied costs. Therefore, to value transportation output in consumer prices, the sales tax (GST) must be added to the hourly cost of providing the service.[8]

**Calculation of the Maximum VCVTS for Trucks**

In Table 2, the maximum values of time of several categories of trucks are calculated using B.C. operating cost figures from Trimac (1990). The trucks are categorized by the type of freight carried (Bulk Commodity or General/Dry Freight). Then, for each category of freight, the trucks are categorized by the number of axles they have (2, 4 and 7/8 axles); and finally, the 2-Axle trucks are broken down by fuel type (gasoline or diesel).

Additional Canadian trucking statistics are from Statistics Canada's "Trucking in Canada" Report for 1988. These include: (1) the percentage of each category of vehicles on the road and (2) the average annual distance travelled. A key assumption is to express vehicle costs on a per hour basis. For this we use an assumed annual utilization of vehicles rather than total hours per year. No vehicle can be used 100 percent of the time. There is down time for maintenance and repairs and, inevitably, there is other unusable "dead time." Some businesses and types of commercial vehicle operations will achieve higher or lower utilization, e.g., some vehicle operators may realize low utilization because they supply firms with restricted business hours. Given the constraints they face, operators are assumed to adjust their vehicle fleet and operating pattern to maximize its utilization. Highway investments improve operating conditions. The assumption is that, in the long run, commercial vehicle operators can adjust their fleet requirements and/or operations to take advantage of improved operating conditions. In sum, these total hourly costs are a long run measure of the resource costs associated with the time-related ownership costs of providing an hour's worth of commercial vehicle service.

Reported annual utilization hours vary substantially among operators. We standardize the assumed utilization hours for several commercial vehicle types. Our calculations are intended to reflect something close to average utilization, although our figures are a matter of assumption rather than empirical result for heavy vehicles, and our sample size is limited for the small vehicle categories.[9]

The hourly cost of a driver (17) is composed of the average B.C. driver's hourly wage (14), and the driver's hourly wage burden (19), which includes items such as fringe benefits and unemployment contributions (Trimac, 1990). The hourly cost of helpers (18) is estimated by multiplying the average probability of a truck having a helper by the hourly cost of helpers. The average probability of a truck having a helper (10 percent) is estimated from Alberta Transportation and Utilities' vehicle occupancy surveys (personal communication). The hourly cost of a helper is estimated to be 50 percent of the average hourly cost (wage plus wage burden) of a driver, is based on our own survey.

The hourly cost of owning a tractor/truck or trailer (10) includes the time-related maintenance costs (5), the time-related depreciation costs (6) and the opportunity or interest cost of the money tied up in the equipment (7). Of course, there is debate over the proportion of different cost categories which are time-related as opposed to use-related. We adopt what appear to be representative figures in the literature: 20 percent of maintenance is assumed to be time-related rather than due to use; 40 percent of depreciation is attributed to time. The sensitivity of the results to the assumptions are readily examined.

The hourly repair cost (5) is estimated by multiplying the average annual repair cost (c) by an estimated proportion of repairs related to time (k) and dividing by the assumed annual utilization time (n).

The hourly depreciation cost (2) is calculated by dividing the annual depreciation related to time by the assumed annual utilization time. The average capital cost of new equipment (a) (from Trimac, 1990), is the basis for depreciation. The annual depreciation (a straight line method recommended by Trimac, 1990) is multiplied by the percentage of depreciation related to time, assumed to be 40 percent (Dawson, 1972, p.3), to calculate the annual depreciation related to time. Again, subsequent analysis can incorporate a range of figures for the depreciation rate related to time.

The hourly opportunity/interest cost of the equipment (3) is based on the average depreciated value of the equipment. This is calculated by depreciating the cost of new equipment (a) by the appropriate depreciation rate (16 percent for tractors/trucks and 12 percent for trailers) for the estimated average age for the equipment. Trimac suggests average ages of 2.5 years for trucks/tractors and 4 years for trailers. The opportunity cost of money is assumed to be 12 percent per annum.

The annual licensing fees (e and f) (from Trimac) are divided by the average annual running time (n) to calculate the equivalent hourly licensing fee (8). The argument is that time savings would mean fewer vehicles on the road thus the license expense is partly escapable. Insurance is influenced by annual distance traveled. By plotting how insurance costs change with mileage increases (from Trimac, 1990) we identified the implicit fixed component of insurance (m). If fleet size were reduced this component of insurance could be avoided. This is the time-related portion of insurance (9).

The hourly ownership cost of the truck/trailer (10) is the sum of items (1...9). The hourly value of truck time is the ownership cost increased to include a profit allowance (estimated by Trimac to be 5 percent of revenues, line 11), plus an allowance for indirect taxes (the GST and provincial sales tax each are 7 percent, line 12). The total cost of driver time (17, 18) is also increased by a profit margin and indirect taxes to express this in consumer prices (21).

The maximum values of time (24) for each category of vehicle are derived by summing the hourly value of driver time plus value of vehicle time. The calculated maximum values for VCVTS for trucks range from $24.94 to $35.82 (1993 $US), depending on vehicle size (weighted average is $30.76). The largest component is the value of driver time. For each vehicle category (bulk and dry freight), ownership costs are relatively higher for smaller vehicles, reflecting the fact that drivers' wages do not increase in proportion to the size and capital costs of commercial vehicles.

**Calculating the Maximum VCVTS for Light Commercial Vehicles**

Heavy trucks are not the only type of commercial vehicle. In British Columbia, vehicles less than 10,000 lbs constitute over 20 percent of total commercial vehicles. Small commercial vehicles perform a great variety of functions, and their owners are a diverse group of busy people. Data on representative vehicles and operating characteristics are harder to come by since there is no central coordinating agency or industry association which might compile such transportation statistics. We surveyed users of light commercial vehicles to obtain needed information. The survey focused on estimates of the costs of vehicles, how those costs are affected by time as opposed to use, and the average utilization of vehicles. A sample of 14 companies with a total fleet of 3625 vehicles was surveyed. The 3625 vehicles were grouped under four vehicle categories reflecting different vehicle designs and use:

1) passenger cars and minivans - i.e., standard passenger cars and small vans

which would be used by individuals, sales agents or representatives, small courier companies, etc.

2) large pickup trucks and cargo vans of about 750-1000 kg cargo capacity, i.e., standard pickup or similar chassis vehicles sometimes with extended bodies.

3) passenger vans on a chassis similar to category (2), typical passenger capacity of 10 to 15 people, such as used for hotel/airport shuttles, or small tour groups.

4) light trucks of less than 5000 kg payload capacity. This is typically a two axle truck, smaller than the smallest truck category in Table 2.

The sample size was very small for passenger cars and vans, so these results have been excluded.[10]

Table 3 reports the figures and calculations for the two categories of light commercial vehicles. Hours of utilization were standardized to be 2400 and 3000 hours for pickups/vans and light trucks, respectively. As before, the maximum VCVTS assumes that time savings can be fully converted to increased output; the minimum VCVTS assumes the opposite and hence only values time savings in terms of the value of personal time to the driver. The minimum and maximum VCVTS are shown at the bottom of Table 3. Recognizing ownership costs (and time-related operating costs) is particularly important for light trucks compared to the pickup/van category. The maximum VCVTS is dominated by the driver-related costs. The maximum values of time savings are $20.15 for pickups and cargo vans and $27.66 for light trucks.

## SENSITIVITY ANALYSIS

The calculations build on a number of assumptions, any of which can be contested. The detailed calculation table (Tables 2 and 3) facilitates examining the sensitivity of the results to various assumptions. Changing the assumed annual hours of vehicle utilization directly affects the overall calculation. If commercial vehicle operators can achieve high levels of utilization, the implied cost and value of time is reduced proportionately.

The sensitivity of calculations to assumptions behind individual components (e.g., the assumed percentage of maintenance costs which are related to time rather than use) is indicated by comparing the size of that component relative to the total costs of vehicle and driver. Labor costs are the most important cost component in the VCVTS.

## USING THE CALCULATED VALUE OF COMMERCIAL VEHICLE TIME

The calculated values for minimum and maximum values of VCVTS are summarized at the bottom of Tables 2 and 3. The VCVTS to be used for project evaluation depends on how efficiently one believes commercial vehicles can utilize the time savings. This could depend on the specifics of the project to be analyzed. There is also a question of whether it is time savings or time delays which are under discussion. There is a possible asymmetry in valuing these two changes, although, in a long run perspective, the differences may be minor.

If carriers could not take advantage of any of the time saved, the drivers (and helpers) would be the sole beneficiaries of the travel time savings. In this case, the appropriate value of time to use in a benefit-cost analysis would be the minimum VCVTS.

If time delays are involved instead of time savings, the minimum VCVTS would seem to be an understatement. Use of the minimum VCVTS for the cost of delays assumes that incremental delays are absorbed by the driver (lost leisure time with no compensation, such as might be expected with owner-operators with a fixed price contract). But it its questionable that delays would have no consequence for or provoke no response by drivers. If, instead, delays are assumed to result in lost incremental output, the appropriate valuation is the consumers' valuation of that output. This is measured by the maximum VCVTS (total time-related vehicle costs including taxation to measure output in consumer prices). The other possibility is that carriers incur costs to offset possible lost output due to delays. With a long run perspective, this approach would also be measured by the maximum VCVTS. This is because there are opportunity costs for the inputs acquired by a firm to offset delays. The usual economics assumption is that inputs can produce outputs elsewhere; these are valued in terms of consumer prices, i.e. inclusive of tax and profit markups. With a long run perspective, this is the maximum VCVTS calculated. If a short run perspective was adopted, the costs of delays might be lower than in the long run, but not necessarily. Short run costs of delays could be higher than long run costs because only limited adjustments in operations can be carried out in the short run.

In sum, it may seem plausible the time savings would not be translated into lost output or cost savings in the short run, but this is less convincing for delays. Lost output or increased inputs to offset delays entail more than uncompensated lost leisure time of drivers. A longer run perspective on costs leads us toward the maximum VCVTS for valuing delays.

The maximum VCVTS assumes that carriers can realize these benefits with no time lag. If this is the case, it matters little whether the benefit to carriers comes in the form of increased output at the same cost, reduced costs for the same output, or some combination of the two. They are measured the same: in terms of the value of equivalent output gained (or lost) due to time savings (delays). If there are time lags in obtaining these benefits, then the appropriate VCVTS would be some fraction of the maximum VCVTS, but it is likely to be well above the minimum VCVTS.

There are further potential complications if the benefits of time savings are from reduced costs rather than increased output. The measure of long run costs (maximum VCVTS) does not include any transactions costs. These transactions costs include the cost of laying off employees, selling unutilized vehicles and any other reallocation costs. These could be substantial and would reduce the appropriate measure of benefits which can be expected via cost reductions from highway improvements.[11] Nonetheless, these transactions costs might not be so important. Many highway investments come about because of rising traffic volumes and delays. Instead of the highway improvement resulting in travel time savings per se, the improvement reduces the increases in travel time caused by increased traffic congestion. Highway improvements benefit carriers by preventing increases in the carriers' costs which would otherwise take place. The transactions costs do not matter here, or they are minimal. Using the long run measure of costs savings is still appropriate. the more rapidly congestion is growing, the more likely a highway improvement will be "preventing an increase in travel time" rather than "saving travel time." Also, the faster that carriers turnover their assets/resources, the faster they will be able to adapt naturally to the time savings.

There is still the possibility that it will take some time for carriers to fully utilize time savings. A possible approach to project evaluation would be to vary the VCVTS and use the minimum VCVTS immediately after the highway improvement is completed, and increase the VCVTS to the maximum value over a period of time. How fast the VCVTS increases might depend on the size of the time savings and the rate of increase of traffic congestion (the extent to which it is delays being avoided rather than time savings per se which is the benefit). However, a changing VCVTS with elapsed time is a complicated procedure, compounded by the fact that many highway improvements are a series of interrelated local projects which could affect the appropriate VCVTS to use. Thus, as a practical matter, adopting fixed values of VCVTS is appealing.

## CONCLUSION

This paper calculates suggested maximum and minimum values for VCVTS in highway project evaluation. We reviewed alternate situations and the implications for choosing a VCVTS such as whether time delays or time savings are involved, and whether it is changes in truck costs or output which are affected. The minimum VCVTS assumes that time savings cannot be used productively at all; the only benefit is the personal convenience of time savings to the driver while working. Conversely, time delays are assumed to only impose nuisance costs on the driver. A longer run perspective assumes that time savings (or delays) save (or consume) resources which can produce additional output. Most of the situations suggest that the minimum VCVTS would be inappropriately low, particularly if one accepts a long term measure. The maximum VCVTS represents an upper limit. Nonetheless, most of the arguments above suggest the appropriate VCVTS would be near the maximum. The final choice requires empirical analysis and/or an administrative decision to adopt a specific value for purposes of project evaluation. For benefit-cost analysis of highways, we are looking at long term effects. Hence we think the appropriate VCVTS is near the upper end of the range of figures we have calculated.

## REFERENCES


Adkins, W., Ward, A., McFarland, W., "Values of Time Savings of Commercial Vehicles", *National Cooperative Highway Research Program Report 33*, Texas Transportation Institute, 1967.

American Association of State Highway Officials, *Road User Benefit Analyses for Highway Improvements*, 1952.

American Association of State Highway and Transportation Officials (AASHTO) 1977 *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements* (Washington, D.C.).

Beesley, M.E. and Reynolds, D.J., "Economic Assessment." The London-Birmingham Motorway: Traffic and Economics, *Road Research Technical Paper No 46*, H.M. Stat., Off., London, 1960.

Charlesworth, G. and Paisley, J.L., "The Economic Assessment of Returns from Road Works", *Proceedings of the Institute of Civil Engineering*, Vol 14, Nov 1959.

Chui, M. and McFarland, W. (1990), "Value of Time and Discomfort Costs, Progress Report on Literature Review and Assessment of Procedures and Data," Texas Transportation Institute, Technical Memorandum for NCHRP Number 7-12.

Fleischer, G.A., "Effect of Highway Improvement on Travel Time of Commercial Vehicles: A Twenty-Five year Case Study", *Highway Research Record No. 12*, January 1963.

Green, F.H., *The Value of Time Saved by Commercial Vehicles as A Result of Highway Improvements*, Unpublished report, U.S. Bureau of Public Roads, 1960.

Hanning, C.R. and Wooton, C.V., "Value of Commercial Motor Vehicle Time Saved", *Highway Research Record No. 82*, 1965.

Hanning, C.R. and McFarland, W.F., "Value of Time Saved to Commercial Motor Vehicles Through Use of Improved Highways", *Texas Transportation Institute Bulletin No. 23*, 1963.

Harrison, A.J. and Quarmby, D.A., *The Value of Time in Transport Planning: A Review*, European Conference of Ministers of Transport, 6th Round Table, Economic Research Centre, November 1969.

Lawson, J.J., *The Value of Passenger Travel Time for Use in Economic Evaluation of Transport Investments*, Economic Evaluation Branch, Transport Canada, TP No. 10568, March 1989.

Lawton, L., "Evaluating Highway Improvements on Mileage and Time Cost", *Traffic Quarterly*, Vol 4, Jan 1950.

Lefevre, P., "The Economic Justification of Road Construction", *Road International*, Part 1, Summer 1956 and Part 2, Autumn 1956.

MVA Consultancy, *et al.* "The Value of Travel Time Savings," *Policy Journals*, London England, 1987.

Miller, T.R., *The Value of Time and the Benefit of Time Saving*, The Urban Institute, Washington, D.C., 1989.

Sugden, R. and Williams, A. *The Principles of Practical Cost-Benefit Analysis* Oxford University Press, 1978.

Trimac Consulting Services, *Operating Costs of Trucks in Canada*, Transport Canada Policy and Coordination, Sept 1990.

Tucker, H. and Leager, M.C., *Highway Economics*, International Textbook Company, Scranton, Pa., 1942.

Waters, W.G., II, "The Value of Travel Time Savings for the Economic Evaluation of Highway Investments in British Columbia", Prepared for: The Planning Services Branch of the B.C. Ministry of Transportation and Highways, March 1992.

Waters, W.G., II, "Variations in the Value of Travel Time Savings: Empirical Studies in the Values for Road Project Evaluation," Working Paper, Faculty of Commerce and Business Administration, University of British Columbia, Vancouver, B.C., and Institute for Transport Studies and Graduate School of Business, University of Sydney, Australia (July 1993).

Wong, Carey, "The Value of Travel Time Savings for Commercial Vehicles in British Columbia," Research Report for the B.C. Ministry of Transportation and Highways, Vancouver: UBC Centre for Transportation Studies (March 1993).

## ENDNOTES

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1. AASHTO (1977) defined the two representative truck categories in terms of gross vehicle weight, specifically 12,000 lbs. and 51,000 lbs.

2. Figures are adjusted to 1990 $US using the consumer Price Index. Figures in foreign currencies usually were converted in the original year dollars and then indexed up. Because this research project has worked in Canadian, Australian and U.S. currency at various times, occasionally a figure in $US might differ slightly from its original published value.

3. For example, see Tucker and Leager 1942, Beesley and Reynolds 1960, Charlesworth and Paisley 1959, Lefevre 1956 and Lawton 1950.

4. Green 1960, Hanning and McFarland 1963.

5. The general sales tax (GST) applies to final sales rather than on intermediate production such as freight transport. However, the freight charges become embodied in the cost of production of the final good and the GST is levied on that final sale price. Hence the GST ultimately does apply to transport, only it is imposed at the point of final sale. This assumes that the tax is borne entirely by the consumer.

6. The treatment of taxation in shadow pricing is discussed in textbooks on cost benefit analysis, e.g., Sugden and Williams (1978) pp. 104-7.

7. With growing traffic volumes trip times may steadily worsen in the absence of highway improvements. But road improvements will improve traffic flow relative to what would have taken place. In urban areas where there is substantial latent demand for automobile travel, the ability to sustain permanent improvements in operating conditions is more debatable.

8. Apparently, excise taxes such as fuel taxes and taxes on batteries, tires, etc. are paid by commercial firms thus embodied in their operating costs. Rather than exclude these taxes and measure inputs in terms of "resource costs," we include these taxes in calculating economic costs. In doing this, we must assume either (1) the taxes are imposed to adjust for external costs such as environmental concerns; and/or (2) the inputs are assumed to be diverted from final consumption goods where the prices paid would have included the taxes. In effect, inputs are shadow priced to measure input costs in terms of the value of

consumption goods, which are gross of tax.

9. Looking at differences in hours of utilization across vehicle types could lead to misleading inferences about VCVTS. Commercial vehicles with low utilization will result in a high average cost per hour. This would imply a relatively high VCVTS. But low utilized vehicles might have a lesser probability of being able to convert time savings into increased output. Conversely, highly utilized vehicles result in a lower average cost per hour, hence a lower VCVTS calculation. But highly utilized vehicles are more likely to be able to quickly convert time savings into increased output. The hourly utilization figures employed here are more representative of average utilization rather than exceptional performance. Further, we use similar utilization figures across vehicle types unless there are compelling reasons for adopting substantially different hourly utilization assumptions.

10. The figures for passenger cars and vans are available in a working paper by the authors.

11. These concerns have been raised in the literature, e.g., Fleischer, 1963; Hanning and McFarland, 1963; Hanning and Wootan, 1965; and Adkins, Ward and McFarland, 1967.