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For-Hire Trucking Price Indices in Canada

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ABSTRACT

This article presents a method of objectively measuring trucking price variations in Canada by constructing price indices. A brief theoretical overview compares the proposed method (that of Törnqvist) with those currently in use. The application of this method to Canadian trucking is then considered in greater detail and compared with the method recently used by M. Boucher as part of a study on Quebec trucking. This comparison illustrates the importance of determining whether a system of revenues or tonne-kilometres will be used for weighting an index, since results differ significantly depending on the system used. Tonne-kilometres weighting appears to underestimate price increases, with respect to Törnqvist's original method, which uses revenues as factors in weighting. The present study also shows an alternative way to obtain series of price indices. This method aggregates the basic series of indices rather than calculating the series from an extensive basic data source. As a result, it enables one to obtain good approximations in respect of a series of price indices based on Törnqvist's original method.

INTRODUCTION

The Motor Vehicle Transport Act, 1987 provides for an overall review of regulations in 1992, with annual reviews prior to that date. One of the key variables in these reviews will be the prices charged for trucking services. There is, in fact, no current method of objectively assessing trucking price variations in Canada.

Measuring objectively price variations is a fundamental activity of economic analysis. This activity entails observing transaction prices at different moments and then assessing the inherent changes. The resulting indices can be employed in different ways. For example, if a particular sector such as trucking is examined, the indices serve to evaluate the impact of evolving competition on user service costs.

Although the objective measurement of price variations is a common economic undertaking, there is no universally agreed upon method for accomplishing this task. This is because the degree of precision inherent in following one particular method and the reliability of the results are often proportional to the cost of its application. Ultimately, a compromise is necessary. The compromise must be sufficiently cost effective to be applicable, while remaining adequately credible to be useful. It is generally recognized that the use of indices permits a rapid determination of the direction and magnitude of price changes. Within such a perspective, this article proposes a methodology that is specifically adapted to the Canadian situation: one in which the government must oversee the trucking industry from an economic point of view, while minimizing operational restrictions for carriers.

THEORETICAL BACKGROUND

Substantial research aimed at identifying the most suitable methodology has been carried out in the field of price indices. Among other things, this research has demonstrated that the Laspeyres and Paasche indices are biased in measuring price variations for a set of commodities or services, because they do not consider substitution effects caused by price variations (e.g., G.Stigler, 1942). The Laspeyres index uses a basket of commodities, representing the quantities of the base period, for weighting price variations over subsequent periods. To the extent that the quantities involved do not vary proportionally with time, the use of a fixed basket biases the results. In reality, the weights associated with elements which become relatively less important should diminish, while the reverse principle applies to elements whose transaction shares increase. Since we know that elements whose prices increase most rapidly tend to diminish their market shares, the Laspeyres index tends to exaggerate price increases. Similar reasoning may be applied to the Paasche Method which uses a basket weighting scheme based on current transactions. The Paasche index thus tends to underestimate past price increases.

I. Fisher [1922] tried to identify an "ideal" index that would be universally applicable by satisfying a set of desired criteria also developed by him. This contribution of Fisher was particularly welcome since the "geometric mean of the Laspeyres and Paasche" indices that he proposed as the

ideal index did not respond to his own set of criteria [see Bryan & Cape, 1982, p.7].

If a price index is not to be biased, it should constantly take price and quantity changes into account. Economic theory consequently suggests the use of an integral Divisia index. This index is not, however, applicable in practice, because the systematic collection and processing of the required data would be too costly. In 1936, L.Törnqvist proposed a discrete approximation of this Divisia index. More recently, Diewert [1978] showed that the index proposed by Törnqvist is a superlative index number and thus possesses all of the qualities associated with such an index. For example, since it is chained, it simultaneously considers price and quantity changes and this would be desirable for the construction of price indices. However, it could prove difficult to apply, because of the need to know transaction prices and their relative importance for each period considered. Despite this inconvenience, the theoretical superiority of the Törnqvist method was significant enough for it to be considered as the one with potential application to the for-hire trucking industry.

APPLICATION TO TRUCKING

In order to apply the Törnqvist method to the Canadian trucking industry, it must be possible to associate prices and revenues for all of the periods falling within the period under study with transactions resulting from the purchase of similar transportation services. Application of the method thus begins by classifying trucking services in order to create relatively homogeneous groups, or in other words, groups with comparable elements. These elements must not, however, be so specific that their prices and quantities cannot be compared for different periods. Defining these groups is a fundamental process which requires in-depth knowledge of the industry. All variables involved in setting prices at a given moment should ideally be used in establishing this classification of services, thus including variables that determine the evolution of trucking prices over time. A study of freight rates within the industry has made it possible to clearly identify the variables to be considered (see V.Wei, 1983).

In the present study, price is expressed by the "cost of the shipment" divided by the product of the "weight of the shipment" multiplied by the "distance travelled." The unit used is thus the cent per tonne-kilometre. It is fairly common in transport to represent prices this way, because doing so enables a shipper to compare costs for shipments of different, but comparable, distances and weights. Despite this fact, given the presence of different economies of scale for these two variables (weight and distance), a system of classification must still be established.

Accordingly, in a recent study, M.Boucher [1988] suggested that four categories of distance and three of weight be used in classifying intercity shipments within Quebec. In addition, he described commodities using their two-digit Standard Commodity Code (S.C.C.) for each category of shipment thus defined, in order to determine the basic elements involved in the calculation. V. Wei's study, for its part, demonstrates (among other things) that the regulatory situation and other economic conditions differ sufficiently from one province to another to warrant being taken into account.

Moreover, certain more qualitative variables, such as the reliability and speed of service may also be incorporated into the classification process. However, the difficulty of measuring such variables and the lack of available historical data are major obstacles to their consideration, even if they may be theoretically justified.

The ideal data base for applying Törnqvist's method to the Canadian trucking industry should thus be sufficiently disaggregated to maintain the possibility of classifying each of the shipments, while at least considering the already-designated key variables:

- **weight** of the shipment
- **distance** travelled
- **province** of origin and destination
- **commodities** transported

If the revenues generated by each of these shipments is also known, the implicit prices of these shipments may be calculated, since:
price = revenue / (weight x distance)

Quantities could also be calculated, since:
quantity = weight x distance.

There is no single source in Canada that can provide this set of data for all truck shipments. However, the Statistics Canada survey on the origin and destination of trucking (TOD) has allowed us to use a sampling process to provide relatively reliable approximations for all of these variables in respect of companies with revenues greater than $350000 within Canada. Thus, the TOD survey data has served as a basis for calculating indices. The period covered by the indices begins with the base year, 1981, and concludes with the last year for which data are available: 1987.

It should be noted that Törnqvist's data is chained. This feature makes the method better suited to the use of data collected through sampling. This is because chaining attenuates the sharp annual variations that may be associated with sampling.

METHODOLOGICAL ASPECTS

Source of Data

A typical origin-destination study collects data on about 600000 shipments that have occurred over a given year. The current method permits data on magnetic tape to be processed about fifteen months after the end of that year. However, a new system is being developed which will provide preliminary quarterly data within a few months of the end of the quarter and thus price indices may be calculated on quarterly bases if deemed desirable.

Classification

Once classified, the shipments fall into about 8000 different groups. These groups are characterized by similar "places," weights, distances and commodities.

Specifically, place is defined according to whether the trip is intra- or interprovincial, as well as according to the provinces concerned. To begin with, six intraprovincial "geographic segments" have been defined: the Atlantic, Quebec, Ontario, Manitoba-Saskatchewan, Alberta and the Pacific. The distinction between trips within a particular province and those outside of it is primarily based on differences between regional regulations. This difference has also resulted in the fact that Alberta may be distinguished from the other Prairie provinces with respect to its intraprovincial segment. Moreover, the small scale and relative uniformity of the Atlantic provinces have resulted in their classification as a single group. Next, eleven interprovincial segments have been defined. These consist of four pairs of trips (eastbound and westbound) between two neighbouring of the five major regions (the Atlantic, Quebec, Ontario, the Prairies and the Pacific); two segments between the provinces of a single region (the Atlantic and the Prairies); as well as a final segment incorporating so-called "long-distance" trips, since they are carried out between two non-neighbouring regions.

We might note the distinction made with respect to general direction (eastbound and westbound). This distinction makes it possible to take into account the potential imbalance in demand for interprovincial traffic between the five major regions. Consequently, the "backhaul" phenomenon that could result from this factor and its influence on prices is implicitly considered.

Shipment within these seventeen geographic segments is further classified with the aid of three classes of weights and four of distances. The definition of these classes are the same as those used in Boucher's study [1988]. In the weight category, less-than-truckloads (LTL) are separated from truckloads (TL). We therefore distinguished between shipments of less than 2272 kg (LTL1) and those of more than 4545 kg (TL) from the intermediate category (LTL2) to establish two LTL categories and one called a truckload (TL). Distances provide for a distinction between shipments depending on whether they fall between 0km and 49km, 50km and 199km, 200km and 499km, or, lastly, more than 500km.

Figures 1 and 2 show the percentage breakdowns of Canadian shipments over the last year for which data is available, 1987, in terms of revenues and tonne-kilometres for the different distance and weight categories, respectively. Different percentages for the same category (i.e., the 500km or more category accounts for 51% of the revenues and 63% of tonne-kilometres) illustrate that average prices are different within the different categories.

The study showed as anticipated, the greater the weight of the shipment and the longer the distance, the lower the price. It may also be noted that the lowest-priced categories (truckloads and distances of more than 500km) dominate Canadian "production" with 89% and 63% of the tonne-kilometres, respectively. The subset defined by truckloads of more than 500km was responsible for 29% of revenues, while representing more than 54% of the total tonne-kilometres produced. A system of classification based on these variables is thus empirically justifiable since: (a) these variables influence prices, and (b) different classes do not have the same degrees of importance.

Calculation of the Indices

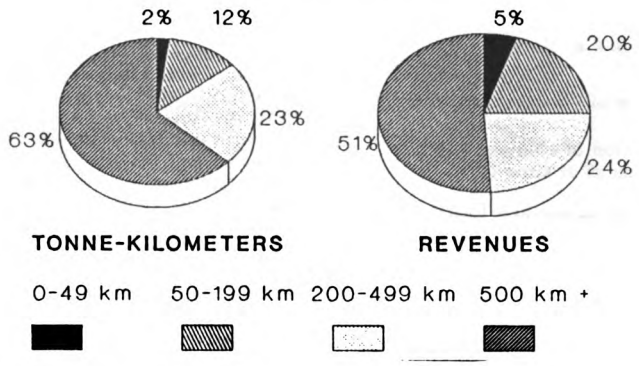
Price indices were calculated on the basis of industry segments defined by the following three variables: three classes of weights, four of distance and seventeen geographic segments. This means that there are 204 theoretically possible segments. However, a detailed quantitative analysis of the segments made it possible to eliminate those whose magnitude was so low that they did not permit application of the method selected. For example, as the number of shipments of less than 50km between two provinces was too insignificant, this category was eliminated from the eleven interprovincial geographic segments. Thus, the number of segments used in calculating the indices was reduced to 151. Despite these reductions, more than 98% of Canadian trucking (in tonne-kilometres and performed by Class I and Class II carriers) enters into the price index calculation.

Törnqvist's formula takes the following mathematical form, according to Diewert [1976, p.123]:

$$c(p^1)/c(p^0) = \pi \left[p_i^1/p_i^0\right]^{\frac{1}{2}\left[S_i^1 + S_i^0\right]}$$

FIGURE 1

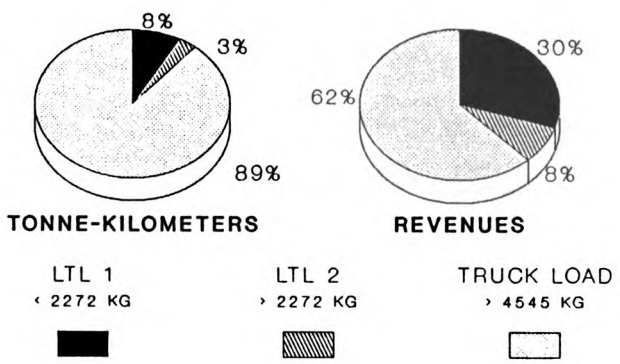
Canadian For-Hire Trucking
1987
Shares by Distance Group



Source: Economic Analysis, Transport Canada

FIGURE 2

Canadian For-Hire Trucking
1987
Shares by Weight Group



Source: Economic Analysis, Transport Canada

However, an algebraic transformation was used in our computer calculations. It was:

$$c(p^1) = c(p^0) \times \exp \tfrac{1}{2} \Sigma \{[1n (p_i^1) - 1n (p_i^0)] \times [S_i^1 + S_i^0]\}$$

In both cases, we have:

$c(p^t)$: price index at time t,

p_i^t: the price of element i at time t,

S_i^t: the portion of element i in the revenues at at time t.

Within the 151 segments, basic elements i are defined by the shipment commodity code (the two-figure Standard Commodity Code or S.C.C.). Obviously, if a commodity code is not present during the current (1) or preceding (0) period, the corresponding element is not used in calculating the index. Consequently, no price with a nil value is used in the calculations.

The weighting variable suggested by Törnqvist is the percentage share of the element in the revenues, or, more precisely the average of current and preceding shares. However, in Boucher's 1988 application of this method to intra-provincial trucking within Québec, he instead used the share of the element in the production measured in tonne-kilometres, as a weighting factor. All of the calculations were made using tonne-kilometres, and then revenues, as weighting factors, so that these methods could be compared.

Index Aggregation

It is not easy to interpret the 151 series of price indices without aggregating them. To this effect, a set of aggregations was produced by sequentially distinguishing geographic segments, weight categories and distances categories. The aggregation was based on the type of weighting used in Törnqvist's method: a moving average over two periods: the present and the preceding one. Algebraically, the aggregation of the series of indices was produced using the following formula:

$$c(p^1) = \Sigma\, c\,(p^1)_i \times \tfrac{1}{2} [S_i^1 + S_i^0]$$

where: $c(p^1)$:the aggregate index at time 1,

$c(p^1)_i$:the index of segment i at time 1,

S_i^t : the share of segment i within the entire set to be aggregated, measured according to revenues (or according to tonne-kilometres production depending on the series of indices to be aggregated).

Some authors contend that calculations of indices applied to specific sectors of the industry would be more desirable if they were formulated using basic elements rather than serving as the subject of a series of aggregations. In fact, the original method proposed by Törnqvist is not using aggregation but rather a direct method to calculate the different indices. For instance, in the case of the price of intra-provincial trucking, all elements concerned by intraprovincial flows in Canada will be used to calculate directly a single series of price indices. These elements are differentiated simultaneously by the four classification variables (i.e. commodity transported, weight category, distance category and geographic segment). Nevertheless, since the aggregation method allows one to do easily detailed analysis of price variation in the for-hire trucking industry from a PC, it is interesting to compare results of the original method with those obtained by aggregation. Thus, four methods have to be compared; the original method proposed by Törnqvist (direct calculation weighted by revenues), the aggregation method weighted by revenues and their reciprocal weighted by tonne-kilometres.

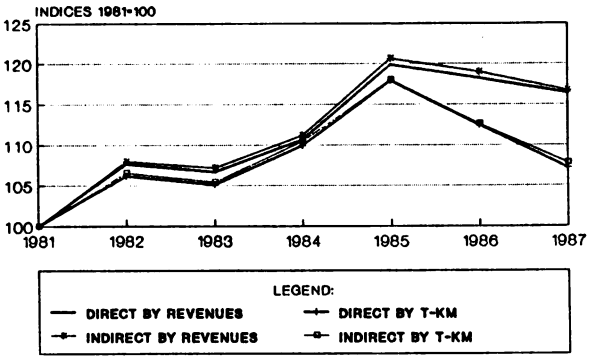
Principal Results

Figure 3 provides various price indices for the for-hire trucking industry in Canada. On one hand, that the tonne-kilometres weighting system tends to underestimate significantly trucking price increases in comparison with a revenue-based weighting. On the other hand, it also shows that the differences due to aggregation of the series is not appreciable, at least for the Canadian industry taken as a whole. It should, however, be noted that the variations take the same direction for all types of indices. The four methods illustrate that the annual average price increase was relatively low over the period studied (between 1.2% and 2.6%, depending on the method used).

Figure 4 illustrates the difference in direct and revenue-weighted price changes for intra- and interprovincial shipments. Price

FIGURE 3

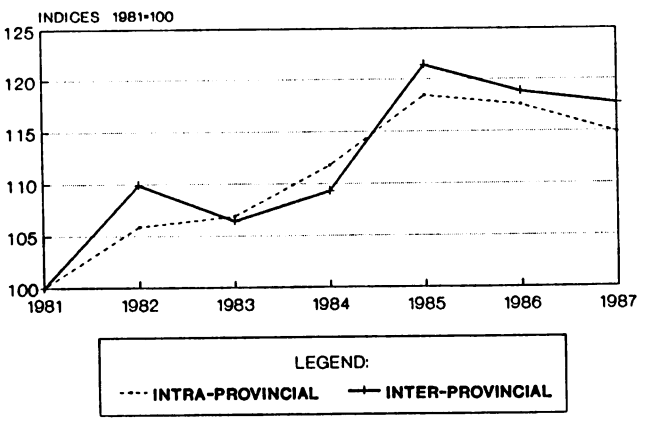
Comparisons of Price Indices Derived From Tornqvist's Method For-Hire Trucking in Canada



Source: Economic Analysis, Transport Canada

FIGURE 4

Price Indices Weighted by Revenues Intra-Provincial and Inter-Provincial For-Hire Trucking in Canada



Source: Economic Analysis, Transport Canada

increases seem to have been similar during the 1981-1987 period for these two major industry segments, even if the interprovincial index is greater than the intra-provincial one. However, the magnitude of variation seems to have been greater in the less regulated market segment (the inter-provincial one).

These two examples provide a brief illustration of the type of analysis that the proposed method of establishing price indices can accomplish. Table 1 provides a series of indices by geographic segment, as calculated by the original Törnqvist method (that is, direct calculation using weighting based on revenue shares).

Rather than providing the 1981 index value in this table (which is obviously equal to 100 throughout the series), the average price expressed in cents per tonne-kilometre is provided to give an idea of price levels for the different geographic segments. This data puts the analysis into perspective since, for example, the segment in which the price increase was the greatest from 1981 through 1987 (shipments from the Atlantic to Quebec) also had the lowest 1981 prices due, at least partially, to a federal program of subsidies. The adjustment could thus be one in response to economic circumstances, rather than being an unusual increase.

Table 2 presents national indices segmented according to distance categories. These series of indices make it possible to monitor the evolution of prices in segments that are very different on this level, as shown by 1981 average prices. This table illustrates that the average prices have tended to increase more rapidly in the short-distance category as well as in the intermediate-weight group.

TABLE 1

PRICE INDICES BY GEOGRAPHIC SEGMENT
Direct Törnqvist Method, Revenue-Weighted
Canadian For-hire Trucking
1981 to 1987
1981 =100

	1981 cents/t-km	1982	1983	1984	1985	1986	1987
INTRAPROV.	10.0	105.9	106.9	111.7	118.5	117.6	114.9
ATL.	9.6	115.9	109.8	120.4	113.3	116.2	113.0
QUE.	10.3	112.1	111.4	117.2	119.9	119.0	114.5
ONT.	10.8	105.2	106.1	110.2	118.5	119.4	125.1
MANSAS	9.3	109.8	110.0	114.8	113.9	111.7	113.7
ALTA	8.6	99.3	101.6	108.0	122.5	118.4	102.9
PACIF	10.2	104.5	111.1	111.5	116.4	113.9	97.7
INTERPROV.	8.1	109.9	106.4	109.3	121.4	118.9	117.7
ATL.	9.9	113.2	120.9	122.0	120.3	120.1	113.3
ATL/QUE	5.3	120.3	122.0	130.3	133.4	136.1	132.4
QUE/ATL	9.2	105.7	108.3	103.9	123.4	115.9	107.2
QUE/ONT	10.0	112.8	107.7	110.5	116.6	122.4	113.4
ONT/QUE	10.9	108.9	99.1	101.8	112.9	112.2	106.6
ONT/PRAI	8.2	116.4	109.7	114.2	131.3	124.3	116.6
PRAIRIES	7.2	109.9	107.1	111.3	112.2	111.6	108.7
PRAI/ONT	6.6	110.2	111.9	116.7	123.0	126.1	116.6
PRAI/PAC	7.1	112.2	104.9	108.4	111.1	109.3	113.1
PAC/PRAI	6.6	106.7	104.4	106.6	112.4	114.5	106.9
LONG.DIST.	7.7	108.6	105.7	107.5	132.9	124.5	111.3
NATIONAL	8.9	107.7	106.7	110.7	119.9	118.2	116.4

Source: Economic Analysis, Transport Canada.

TABLE 2

PRICE INDICES BY DISTANCES AND WEIGHT CLASSES
Direct Törnqvist Method, Revenue-Weighted
Canadian For-hire Trucking
1981 to 1987
1981 =100

	1981 cents/t-km	1982	1983	1984	1985	1986	1987
1-2271 kg	28.4	109.5	107.8	112.3	128.8	130.0	131.4
0-49km	190.1	103.4	97.4	105.7	112.7	111.6	110.6
50-199km	91.4	107.7	106.3	110.6	116.5	125.7	127.1
200-499km	42.7	107.3	109.1	115.1	123.8	131.1	132.0
500km +	20.8	111.3	107.9	111.6	136.1	131.6	133.1
2272-4544kg	16.5	111.5	115.9	117.9	124.7	129.8	135.6
0-49km	54.8	116.8	119.1	121.2	111.9	136.7	151.1
50-199km	39.1	106.6	113.1	110.1	118.7	126.3	122.9
200-499km	21.3	115.8	119.2	122.8	126.7	133.7	127.5
500km +	13.3	110.9	115.4	117.8	126.0	129.0	138.9
4545kg +	6.1	106.2	105.1	108.9	114.5	110.8	107.0
0-49km	16.2	107.0	104.4	111.1	119.8	120.8	120.7
50-199km	9.9	103.8	102.6	107.2	111.4	107.6	107.8
200-499km	6.5	106.8	108.2	108.2	113.8	108.8	100.6
500km +	4.9	106.9	104.6	110.0	115.9	112.5	108.6
NATIONAL	8.9	107.7	106.7	110.7	119.9	118.2	116.4
0-49km	22.1	106.6	103.4	110.2	118.0	119.5	120.0
50-199km	14.1	105.1	104.1	108.3	113.2	113.3	113.6
200-499km	9.7	107.5	109.1	111.3	117.9	117.3	111.5
500km +	7.4	108.9	106.8	111.3	123.8	120.6	119.3

Source: Economic Analysis, Transport Canada.

CONCLUSION

To the extent that the Statistics Canada's survey of the origins and destinations of commodities transported by truck (TOD) reflects actual developments in the evolution of for-hire trucking prices in Canada, the Törnqvist method, as presented here, may provide effective tools for measuring variations in these prices. The revenue weighted method is probably preferable to the tonne-kilometres method, since the index the former produces fulfills the criteria of superlative index numbers. The creation of a series of indices for large industry segments through the simple aggregation of the indices of its components had been the focus of a detailed empirical analysis that assessed its validity and at a certain confidence level.

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ENDNOTE

* Transport Canada