Assessing the Impact of Weight and Dimension Regulations: Methodological Considerations

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ABSTRACT

Over the past fifteen years there have been tremendous changes made to Canada's vehicle weight and dimension regulations. Many of these changes have occurred because of a general acceptance of the proposition that larger trucks are more productive than smaller trucks. Various regions of the country have played a game of "catch-up" with other regions of the country and/or have accepted the trucking industry's views about larger trucks in the belief that allowing these larger and heavier vehicle combinations on the road will produce a variety of "benefits."

Somewhat surprisingly, except for the often demonstrated "theoretical" or "potential" productivity advantages of large/heavy trucks, the amount of research in Canada on the precise consequences of allowing different types of combinations on the road is poor. This deficiency in the research is not necessarily for want of trying. Rather, data limitations, political considerations, and simplistic assumptions have been prime contributors to the questionable research efforts.

In this paper, a critical assessment of previous Canadian research is made. In addition, selected foreign approaches have been examined where appropriate.

1. INTRODUCTION

The proposition that larger trucks are more efficient than smaller trucks is widely held in Canada. It lies at the root of a long process of gradually increasing allowable truck weights and dimensions. Currently, Canada has some of the world's heaviest, largest trucks operating on its highways.

This proposition can be examined at several levels of detail. At the simplest, savings in truck operating costs per unit of output are used most frequently to measure the benefits of allowing larger trucks. (Trucking rates are sometimes used as an equivalent formulation, given certain assumptions.) At more complex levels, the following costs can be added to the numerator of this ratio:

- Highway costs (pavements, bridges, geometry)
- Traffic costs (all things associated with vehicle movement, such as congestion, safety, emissions)
- Diversion costs (costs that arise from inter-modal shifts in freight
- Shipper costs (storage, handling and other distribution cost effects)
- "All-other" costs (a catch-all for all other changes that result from changing and/or different weight and dimension regulations: the cost of more or less uniformity in regulations between jurisdictions; the impact on regional economies of expanding or contracting the transportation links with other regions; the cost of increasing or decreasing competition among the different modes of transportation, and so on.)

Whether or not the "larger-is-more-efficient" proposition holds through this full range of possible measures is debatable. Certainly in the Canadian context, research is not far enough advanced to provide an answer.

Most Canadian research has been limited to either the first or the second level of detail outlined above

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– that is, either measuring truck operating costs (or rates) that change with changing regulations, or measuring reductions in trucking costs (viewed as the "benefit" side of relaxing weight and dimension regulations) and comparing these to increases in highway costs (the "cost" side) resulting from the strengthening and/or improvement required to implement the new regulations.

In this paper, an assessment of this research is made with most of the concentration on truck operating costs (or rates). Others are currently engaged in addressing the pavement/structures side of the issue; and almost no work has been done in Canada on traffic, diversion, shipper, or "all-other" costs. Principal concerns are: how are benefits defined? what method is used to develop estimates of these benefits? what critical assumptions are used? and what are the major limitations?

Although the interest is in Canadian research, an effort has been made to compare the scope and quality of this research with that from other countries; there was no intention of providing a full critique of the non-Canadian material.

2. BACKGROUND

Canadian research into the benefits of relaxing weight and dimension regulations is a relatively recent phenomenon – it was only 13 years ago when the first study of the issue was undertaken. Th reason for this and subsequent studies has been the very significant increase in truck sizes and weights that have been allowed over the past few years. A summary of some of these is shown in Table 1 (more detail is provided elsewhere). (1) There are some missing values in this table; however, the percentages shown -- particularly those for single-axle loads, tandem-axle loads, and gross vehicle weight ("GVW") – indicate the extent of the changes that have occurred.

Each row in the table shows the changes in the provincial or territorial regulations. Current regulations, which differ from one province or territory to another are far more complex than suggested by the nine columns. However, these nine columns show the changes in the main components of the regulations in Canada: vehicle height (4.15 metres is common), vehicle width (2.6 metres is standard in 11 cases), tractor and truck length (12.5 metres is common), full trailer length (12.5 to 14.65 metres, depending on the province or territory), semitrailer length (13.5 metres to no limit), combination lengths (20 to 23 metres in many cases with longer lengths allowed under permit), single-axle (non-steering) loads (9,000 to 10,000 kg in most cases), tandem-axle loads (16,000 to 20,000 kg in most cases), and GVW (up to 63,500 kg). A more complete description of these regulations by the authors is available, although even at 90 pages in length it has not been

Table 1 — Changes in Canadian allowable weights and dimensions

	Percentage change in allowable weights and dimensions: 1970-1985								
			Lengths				Loads		
Prov./ Terr.	Height (%)	Width (%)	Truck Tractor (%)	Trailer (%)	Semi-Trailer (%)	Com-bination (%)	Single Axle (%)	Tandem Axle (%)	GVW (%)
Nfld.	0.9	0.4	2.5			6.0	10.2	24.0	68.3
P.E.I.	1.8	0.4	14.4			-13.0	11.5	24.7	59.4
N.S.	0.9	0.4	2.5		20.2	6.0	10.2	17.1	49.0
N.B.	0.1	0.4	?	31.2		14.8	10.2	24.0	68.3
Que.	0.9	0.4	17.2	37.3	45.3	16.1	22.5	47.0	71.3
Ont.	0.9	0.4	17.2	17.2	6.8	16.1	22.5	31.6	20.7
Man.	0.9	0.4	2.5			16.1	11.5	10.2	68.3
Sask.	0.9	0.4	17.2			16.1	11.5	10.2	59.4
Alta.	0.9	0.4	–			16.1	11.5	10.2	63.8
B.C.	0.9	0.4	17.2			16.1	11.5	17.1	84.2
N.W.T.	–	–	–	–	–	–	–	–	–
Yukon	– 1.6	0.4	17.2			11.0	22.5	31.6	90.4

possible to deal fully with many aspects of what are an extremely complex set of regulations. (2)

3. PREVIOUS CANADIAN RESEARCH

3.1 OVERVIEW

This review of previous research is organized as follows: research resulting from a federal-provincial highway strengthening agreement in Western Canada (Section 3.2); research resulting from a similar agreement in Atlantic Canada (Section 3.3); and all other research not directly associated with either of these highway programs (Section 3.3).

In terms of what constitutes "previous Canadian research", it is impossible to draw hard boundaries. There are, however, some points to note about the process of identifying the research of interest. First, attention is focused on research in the public domain. Some provincial departments have done in-house work that has not been reviewed. Second, many reports on road-side surveys are not covered in this review. The exceptions are where there was a clear intent to develop data for research into the impact of weight and dimension regulations. Third, excluded from this review are all of the "simulations" which "demonstrate" the theoretical or potential productivity advantages of large trucks (unless, of course, these were part of a larger research effort directed at developing an estimate of the total impact of a change in the regulations).

Finally, in terms of format, the following descriptions tend to be longer at the beginning of the paper than at the end. This is because there are many similarities in the existing research and there is no point repeating some descriptions over and over. The space given to various studies and/or papers has nothing to do with the importance of individual works.

3.2 WESTERN CANADA HIGHWAY STRENGTHENING PROGRAM

As part of the federal-provincial agreement, each of the three Prairie provinces was required to forecast the benefits that would result from strengthening primary highways and allowing larger and heavier trucks. For this reason the first step in the research process in Canada was a cooperative effort to collect the necessary data in a large-scale road-side survey. (3)

1973 Western Canada O/D Survey

As with any road-side survey, there are "administrative problems" evident in the resulting data base (sloppy coding or missed observations). There is, however, no point in criticizing these aspects of the data base. A more serious criticism is that the one-week, 24-hour/day survey of 28,813 truck trips collected information on all the standard truck characteristics (axles, registration, O/D's, commodity, registered weight, payloads, and so on) without a clear sense of how the resulting data could best be used. In retrospect, the research that followed would have been better if methodologies for measuring various changes to trucking activity had been developed prior to the survey. (For example, four truck types is a limited way of describing all configurations on the road: with the benefit of hindsight, it is evident that more refined configuration characteristics are required to enable a full understanding of the complex changes to trucking fleets that occurred as a result of this program.)

There are three other points to note about this survey. First, the exclusion of some types of truck activity (trips with a distance of less than 40 km) distorts the picture of truck activity that emerges: for example, commodity movements such as aggregates (dump trucks) are under-represented. Second, the survey technique allows for the counting of some trips more than once. That is, during the survey week, a truck moving from Ontario to British Columbia might have been counted six or seven times (depending on the route). Third, the original data tapes appear to have been either lost or destroyed. Whatever the case, they are unavailable to anyone wishing to go back to the raw data to develop new information.

1973 Alberta Study

This data was used first in an Alberta study. (4) A profile of nine truck/commodity hauling situations was developed (for example, tractor-semi-trailers hauling heavy machinery, building supplies, and other similar commodities), and five regulatory scenarios were examined -- one of the scenarios being the base or current case, and the other scenarios all contemplating higher axle and/or gross weights.

Benefits were defined as the difference in truck operating costs under each of the regulatory scenarios -- that is, the difference in truck costs per tonne-kilometre ("tn-km") between the type of trucks allowed under one of the scenarios versus the trucks operating under the base case. Since the authors of the study felt that it takes about five

years for the full effects of changes in the regulations to be felt (i.e., for the industry to re-equip), all forecasts were made for a period five years in the future.

Freight for each of the nine truck/commodity categories was assumed to grow at an annual rate of 6% for five years. This freight was then redistributed among trucks that were assumed to handle larger payloads (depending on the regulatory scenario). The new payloads were calculated as a certain percentage of the maximum possible payloads under each scenario (in other words, an allowance was made for partial loads). The study was vague as to the precise characteristics of these new fleets. The only hard information provided was the new payloads assumed under each of the scenarios. For example, if Alberta adopted the then current Ontario regulations, payloads for the tractor-semitrailer-hauling-heavy-machinery . . . group would increase from 14.7 tonnes to 31.5 tonnes. Payloads of this size (and this is only 74% of the maximum payloads assumed) cannot be handled by the current standard 5-axle equipment. The study made some general reference to new configuration types that are likely to emerge, without providing specific details.

The lower cost per tn-km characteristic of larger trucks was used to convert this forecast freight flow to the inferred benefit of each of the regulatory scenarios (i.e., as the difference in costs between one of the scenarios and the base case cost). In fact, there were a few other steps in this process: costs were inflated at 5% annually for five years into the future (a pointless step); the resulting dollar estimate of benefits was expanded by a factor of 2.56 to account for the fact that the O/D survey was estimated to have captured only 39% of the truck movements in Alberta; the results were further expanded by a factor of 51 to account for the fact that the one-week survey was estimated to represent 1/51 of a year's truck movements; and, the estimated benefits were developed for two categories of traffic -- "all" and only that with an O/D in Alberta. The rationale behind this last point was that if neighboring provinces did not also adopt one of the new regulatory scenarios, trucks with an O/D outside the province would remain the same size as the base case.

With all the estimating/expanding/inflating, it is not clear that the final results have much meaning. At best, the study starts with the proposition that larger trucks can (and will) haul freight at a lower cost than smaller trucks and ends many pages (and assumptions) later with a restatement of the obvious.

But setting this objection aside, there are some specific points about these procedures that require comment. First, a critical assumption is that average actual payloads will increase dramatically under any of the potential regulatory changes. This increase was assumed to occur because trucks under the various scenarios are assumed to load to the same proportion of potential maximum loads as trucks under the existing regulations. In other words, if trucks now load on average to 75% of their potential weight capacity, it is assumed that the new trucks will also. A problem with this assumption is that it ignores the density characteristics of freight. That is, since only axle and GVW limits and not dimensional limits (height, width, length) were increased under the alternative scenarios, it would be unlikely for payloads of the less dense freight (e.g., feathers) to increase under the new regulations.

Second, although the mandate for this study seems to have ruled out any consideration of impacts other than truck operating costs (e.g., highway/traffic/diversion/etc.), it is still to be noted that the sole consideration of benefits is the lower costs per tonne-kilometre of a large truck in comparison to a small truck. Except for brief speculation, there is no consideration given to operating costs other than over-the-road, or linehaul costs. No account is taken of possible operating changes that might occur (terminal operations, consolidation, pickup and delivery procedures, scheduling considerations, etc). Further, no consideration is given to shippers' desire for larger payloads (shipments), or the degree to which operating cost reductions will be passed on to shippers, etc.

1973 Saskatchewan Study

The next study modeled itself after the Alberta one and added a number of improvements. (5) The similarities include the use of the same data base, the estimation of benefits five years in the future, the use of similar vehicle cost data, and the calculation of benefits as the difference in transportation costs between two regulatory scenarios.

There are, however, some differences in the Saskatchewan approach. First, using more refined data on estimated annual truck distances (by truck type) and vehicle registration data, the study characterizes truck activity in more realistic terms than was the case in Alberta. This more complete data is used to account for some of the truck

activity under-represented in the O/D survey (in particular, the smaller straight trucks used on local hauls), and to make educated guesses as to what type of truck activity might take advantage of higher axle or GVW limits (it is considered unlikely that truckers hauling bulky (low-density) commodities would change their operations). In addition, and although these do not enter the explicit calculation of benefits, there is more attention given to some of the considerations omitted from the Alberta study: discussion of the great difficulty in speculating on the actual fleet mix that will occur given a regulatory change; discussion of some of the benefits omitted from the calculations (for example, a more competitive truck/rail environment); and, a lengthy calculation of the revised road-user taxes that should be implemented if the regulations are altered.

Despite these improvements, the same comment made about the Alberta study applies here: any study starting with the proposition that larger trucks can haul freight at a lower cost per tonne-kilometre than smaller trucks is bound to "prove" that there are benefits to any regulatory scenario that permits larger/heavier trucks. The only question to determine is the size of this benefit (or the willingness to make assumptions). However, the Saskatchewan study takes a more cautious approach than the Alberta study to the issue of truck activity in general and the amount of freight that will "shift up" in particular. Nevertheless, it still does little more than prove the obvious.

1973 Manitoba Study

The third provincial study has never been released to the public. However, from references to it in other government documents (6), it appears that the methodology was very simple and can be dismissed from consideration here: a constant amount of freight is divided among fewer truck trips under alternative regulations and these fewer trips are costed at the same rate (per kilometre) as the current truck trips to arrive at an estimate of the benefit. (Note the apparent assumption that truck costs per unit of distance are invariant with truck size.)

These criticisms of the three Prairie studies -- and, in particular, the criticisms of the Alberta and Saskatchewan studies -- might be unfair if the purpose had been to provide estimates of the dollar amount of benefits so that governments could compare these with the cost of highway upgrading. The problem with this argument, however, is that there is no evidence that the results of this research were ever used by either the federal or provincial governments to evaluate these highway programs. (7)

1978 Western Canada O/D Survey

In 1978, a second O/D survey was conducted for the purpose of developing information on how truck activity had changed since the 1974 increases in axle and gross weight limits on primary highways. (8)1 The survey effectively repeated the earlier 1973 O/D survey, although the scope was increased slightly (minor changes in the weigh scales), the number of observations increased (52,014 trips versus 28,813), and some modifications were made to the survey procedures (a method was developed to eliminate, more-or-less, double counting).

The wealth of material collected in this survey constitutes one of the better data bases in Canada for examining how truck characteristics have both changed since 1973 and how truck characteristics in one province compares with characteristics in another. Everything from the steering axle loads of various truck configurations or various truck body styles in various provinces to a complete commodity O/D matrix is available.

On a less positive note, the main volume of this report does not make full use of the massive amount of data collected. That is, while interesting comparisons of 1973 and 1978 data are made, there is no attempt to draw a line between changes in truck characteristics that might be related to changes in weight regulations and those changes that might have occurred for other reasons. Further, those changes that are quite clearly related to the changed regulations are examined superficially.

To elaborate on these points, the many pages of detail on traffic patterns -- more of commodity X is moving between provinces A and B in 1978 -- is interesting, but no explanation is given as to whether or not this change in flow is related to the improved primary highway system and the higher loads allowed: did the regional economy expand because of the regulatory change? did some of this traffic shift from rail to truck? or, were all of these changes a simple function of the rapidly expanding resource-based economy in the 1970s? The fewer pages of detail on changes that are clearly

1 A third report on Western Canada O/D surveys in 1974 has been omitted from this discussion.

related to the new regulations are more interesting, but with only two exceptions the data available is not used. The two exceptions are where evidence on increasing registered weights of trucks are related to particular kinds of truck activity (liquid and dry bulk trucking) and where some tentative evidence is presented suggesting that more freight is cubing out in 1978 than in 1973. But these are the only two instances where this happens. More generally, it is apparent that there has been some change or it is apparent that there are some differences among the provinces, and no attempt is made to produce cross-tabulations that might shed light on the phenomena: for instance, why did the use of straight trucks generally fall between 1973 and 1978, but increase in some provinces? why are axle weights higher in some provinces than in others?

Finally, and as with the 1973 O/D survey, the most serious criticism is that with the increased understanding about this subject that has occurred of late, no one has ever attempted to go back and re-massage this data base to develop new information or to explore more intelligent hypotheses than those originally formulated. Further, it is not clear that anyone could do this: the location of the tapes is unknown.

1983 Saskatchewan Secondary Roads

In the next study emanating from Western Canada, an estimate was made of the benefit of increasing loads on secondary highways in Saskatchewan (bringing GVW's, but not axle loads, more-or-less up to primary highway levels). (9) The methodology is described as "quick and dirty". It entailed making an estimate of major commodity movements on the secondary highway system (the data source being the 1978 O/D survey); making an estimate of the amount of this traffic that might move in larger payloads; and converting the resulting freight estimate into a "saving" on the basis of an estimated 23% reduction in per unit costs on the larger vehicles.

The significant point is that there is no evidence that the simplicity of this analysis (and the minimal effort that went into it) produced any worse (or any better) estimate of benefits than any of the more elaborate studies.

1983 Western Canada Overview

In 1982/83, the authors themselves became involved in research aimed at understanding the effect of the regulatory changes in Western Canada. (10)

The research proceeded by developing and attempting to test a series of hypotheses. The first was that if there had been any benefit to the relaxed regulations, evidence for this would have to show up in vehicle registration data and in the on-road truck surveys the provinces periodically conduct. The second was that the existence of larger/heavier trucks was not sufficient for the realization of benefits; there had to be in addition some evidence to indicate that payloads and/or shipment sizes increased. The third hypothesis was that if there were any benefits to the shippers, this would have to show up in the form of lower rates and/or better service (or, in the case of private trucking, lower distribution costs). The aim of the research was to look at any and all indicators for evidence of these effects in response to changes in the weight and dimension regulations.

In pursuing these hypotheses: (i) for the first time attempts were made to use Canada's national truck data base (Statistics Canada) in addressing this issue; (ii) attempts were made to use provincial registration data; (iii) attempts were made to expand the use of road-side survey data (combining it with the 1973 and 1978 O/D survey data); (iv) attempts were made to use published truck tariffs in order to see if changes attributable to changing weight and dimension regulations could be detected (were rates reflecting the larger possible payloads?); and, (v) possibly of greatest interest, attempts were made to develop some case study information that would expand the understanding of the relationship between regulations and trucking activity.

The success of these various attempts was uneven; nevertheless, the exercise was valuable. The work demonstrated that up to eight years after the regulatory change, important adjustments to the trucking fleet were still occurring; that "pass-through" benefits to the shipper were highly varied with respect to timing, commodities, and traffic lanes; and further, that the data shortcomings rendered even post-mortem evaluations of regulatory change difficult. This convinced the authors that the large "macro" exercises are limited in their ability to explain the complex relationships between trucking activity and weight and dimension regulations.

3.3 ATLANTIC CANADA HIGHWAY STRENGTHENING PROGRAM

A further series of federal-provincial highway strengthening agreements in Atlantic Canada resulted in increases in allowable truck weights

throughout the region and another series of studies. The basic premise in this research is similar to that used in Western Canada: benefits are the difference in trucking costs under various scenarios allowing different trucks to operate.

1976 Atlantic Canada O/D Survey

The research began with an O/D survey, which was conducted on a 24-hour, 7-day/week basis (some exceptions) at 36 survey points. (11) Information collected from 64,956 interviews included the usual characteristics obtainable from roadside surveys. After various adjustments, the results were expanded to 3.3 million annual truck trips.

In terms of methodology, this survey solved the problem of double-counting by adopting the simple technique of asking drivers whether or not they had been interviewed previously on their current trip (roughly one in five had). An impressive aspect of the Atlantic O/D survey is the method used to expand the results to annual volumes. These are too complex to describe here, but it can be noted that this is one of the few such data bases where the problems created by seasonal factors (a major issue in Canadian trucking) seem to have been accommodated. The major criticism of this work is the apparent lack of purpose in much of the analysis. That is, if the aim of doing such surveys is to develop data useful for understanding weight and dimension regulations, the vast effort put into the development of data unrelated to the subject at hand has to be questioned. Pages and pages of information on hourly variations in truck flows and very detailed commodity O/D matrices are all, perhaps, useful; unfortunately, their relationship to weight and dimension regulations is left unexplained.

1977 Atlantic Provinces Benefit Study

The first study to make use of the 1976 Atlantic O/D survey evaluated the impact of adopting the uniform weight and dimension regulations in Atlantic Canada. (12) The methodology involved the development of an elaborate zone/centroid/link-distance map of truck activity. For nine truck types, average payloads were calculated; then, under the assumption that truck characteristics would become identical to those observed on the "optimal link" -- New Brunswick highways where higher axle/GVW limits had been permitted for some time -- the commodity flows were redistributed across truck types, by stage length. Notice that the model of truck activity has become much more elaborate since the first study in Alberta.

Using information on operating costs, fuel consumption and operating hours, total costs, fuel, and hours are estimated for the fleet handling this redistributed freight. These procedures result in two sets of estimates: the existing system, and the optimal system (i.e., "optimal" in the sense of exhibiting the characteristics of the "optimal links" in New Brunswick). The differences between these two are the estimated benefits of the proposed regulations. There are various other refinements such as extrapolating for 20 years under various traffic growth factors, discounting (the cost estimates), etc.

There are some weaknesses in these procedures: the estimation of traffic for 20 years, the lack of data on true trip lengths or out-of-province O/D's, etc. But these are relatively minor points. A more serious weakness concerns the basic assumption employed -- that truck characteristics on existing "sub-optimal" links would change to the characteristics observed on the New Brunswick "optimal" links. This attributes the cause of all these characteristics to weight and dimension regulations. In fact, there are other factors at work: shippers' demand; differences between inter-regional flows versus intra-regional flows; etc. Further, there is no recognition (with this assumption) of the "response time" required by the trucking industry; nor is there any recognition of the possible effect the "sub-optimal" routes were having on truck characteristics on the "optimal" routes (i.e., the regulations on non-designated highways can be expected to have a major influence on truck types and payload sizes on the designated system). Finally, the overlapping nature of the estimated benefits (operating cost, fuel consumption, operating hours) is peculiar: no rationale is provided for making these three separate estimates, nor is there any apparent use of some of the resulting numbers.

1980/81 Provincial Studies

At the completion of the first phase of the highway strengthening program in Atlantic Canada, the provinces were required to evaluate the success of the program. Unfortunately, asking a province to conduct a study as to whether or not it benefited from the receipt of federal money in Canada does not produce particularly "hard" analysis. With one exception, this research is fairly thin. (13)(14)(15)(16)

All four studies used their own road-side surveys conducted in 1979 to compare with the 1976 Atlantic O/D survey. The amount of information collected was limited; the only thing that can be

determined about the effect of the regulatory change is that there had been some change in the mix of configuration types (straight truck versus tractor-semitrailer, etc.) and average weights. What is disappointing is that where the results appear to diverge from the "optimal-link" characteristics (predicted in the earlier study), no comment or explanation is attempted. The studies also used a list of published trucking rates to "demonstrate" that larger shipments get better rates than smaller shipments. This is not a surprising finding, nor is it a convincing demonstration of the actual effect of changing regulations.

The one study that stands out does so because an attempt was made to relate the observed truck characteristics with the regulations. Some of the observations made (these tend to be speculative) reinforce the notion that there are many aspects about the subject that are poorly understood -- for example, why average payload size might fall instead of increase after allowing higher axle/GVW limits.

1985 Atlantic Canada Benefit Study

Finally, the latest research from Atlantic Canada (including the reported results of a 1984 Atlantic O/D survey) had as its purpose the estimation of benefits from a number of improvements to the highway system. (17) Only those improvements associated with increased weights allowed under the revised regulations are of concern here.

The 1984 O/D survey itself was similar to previous ones, although the improvements in various administrative procedures probably resulted in a more accurate data base. Many of these administrative procedures do not need to be described, but one is worth noting. The surveys were conducted during three seasons of the year and this technique, in addition to various control counts, allowed the researchers to focus on producing what are assumed to be fairly accurate annual descriptions of truck activity in Atlantic Canada.

Having noted this improvement in technique, it must also be noted that the amount of detail collected on truck characteristics remains disappointing. Only the barest of detail was collected on configuration type, number of axles, truck weight ("maximum allowable," actual, and tare -- often, apparently, estimated). Information on commodities, O/D, trip details, and some aspects of vehicle ownership was also collected.

The methodology used to estimate benefits is similar to previous studies from Atlantic Canada. Essentially, benefits were the difference in operating costs over a twenty-year period under two scenarios: the old and the new regulations. Again differences in fuel consumption and vehicle operating hours were calculated for no apparent reason. The survey data was used to calculate an elaborate O/D matrix showing truck trips by six truck type. Given certain assumptions (and the various empirical measures developed from the 1976 and 1984 surveys) the model worked by developing estimates of annual truck trips between each O/D pair with two key factors changing (or, in the base case, not changing): average payloads for each of the truck types; and, the proportion of freight moving in each of the six truck types.

3.4 OTHER RESEARCH

In terms of research not directly or exclusively associated with either the Western or Atlantic highway strengthening programs, there are three points to make.

Provincial Surveys

First, most provinces conduct some form of roadside survey on a fairly regular basis. Generally, these are not specifically concerned with the relationship between weight and dimension regulations and trucking characteristics (although quite often they develop data that can be used in this area). For this reason, this research is not described here. On occasion, though, some of these surveys resulted in public reports which do include some examination of the subject of interest here. An example of this is the most recent survey from Ontario (18); other provinces (Alberta is a good example) are known to have produced in-house documents containing even better time-series data on changing fleet characteristics.

Shipment Data

Second, one other area of research deserves note, not because the results were particularly important but rather because this was the first attempt to treat the subject on a national basis. (19) Briefly, using Statistics Canada sources, data was developed on average shipment size and changes in average shipment size for all provinces in Canada. The results showed that there was some relationship between changes and/or differences in weight and dimension regulations and shipment sizes that coincided with a priori expectations. Nevertheless, this method is inherently limited by its inability to isolate the impact of

weight and dimension regulations from all the other factors affecting shipment size.

National Fleet Characteristics
Third, there has been one attempt to develop a comparison of fleet characteristics in various parts of the country through the use of "impressionistic accounts" (from truckers) of truck usage. (20) The results sometimes contradict the results obtained from road-side surveys (see (1) for an account of where it has been possible to check these results). This methodology has limited application in this type of research.

4. SELECTED FOREIGN APPROACHES

To compare Canadian research with research in other countries, four non-Canadian studies have been reviewed -- three from the United States and one from the United Kingdom.

1968 U.S. "Economics of Maximum Limits" Study
Robley Winfrey's 1968 study is the appropriate place to start. (21) That is, with one exception, this study was the first U.S. study to examine the issue of weight and dimension regulations from the perspective of truck operating costs. Previous research had concentrated solely on highway and safety costs.

There are three points about this work that are in sharp contrast to Canadian research. First, the study develops national truck and highway costs at a disaggregate level (various highway systems, various geographical regions, and truck data developed from surveys conducted by 46 states). There have been few attempts in Canada to look at the benefit side (i.e., for hire, truck operating costs) of this issue on a national basis.

Second, the scope of the Winfrey study is far beyond anything attempted in Canada. While the two primary considerations -- truck operating and highway costs -- are familiar enough, the back-up for these areas is far more extensive than anything yet undertaken in Canada: there are background reports and studies on traffic forecasts, truck weight frequencies and ADT composition by road system, braking performance, offtracking, the relationship between GVW and horsepower, accident experience, pavement design, geometric design, linehaul trucking costs in relation to GVW, and so on. (It must be admitted, that as these background reports have not been reviewed, no information is known about the quality of this research.)

Finally, the most striking contrast with Canadian research is the purpose of the Winfrey study -- the determination of desirable weight and dimensional limits by comparing trucking economics with highway economics. That is, unlike most Canadian research, the study does not concern itself with specific weight and dimension policies; rather, the aim of the research is the determination of some optimum in the policy.

1981 U.S. "Truck Size and Weight" Study
The methodology of the second U.S. study is the development of costs and benefits resulting from a set of alternative changes to the federal limits on truck size and weight. (22) The major element of benefits is the change in truck productivity. Other than the fact that some of the alternatives contemplate a reduction in weight limits, there is nothing in this methodology that is startlingly different from Canadian research. There are, however, some points to note.

First, Canadian researchers are not alone in having "data problems". In fact, from the summary in the main volume of this U.S. study (i.e., without reviewing the actual data), it appears that American researchers have even greater problems with data than Canadian. One of the major sources of information used to project 1985 levels of truck activity is a 1977 data source (TIUS) that provides information on the total size and characteristics of the U.S. truck fleet.

> "This data set represents the best source for total number of trucks by body type, vehicle miles of travel, major use and other characteristics. However, it does contain several serious shortcomings that require adjustment. The 1977 TIUS showed a total of about 824,000 tractor-semitrailer and truck-full trailer combinations. All other sources indicate that there were between 1.2 million and 1.4 million combinations . . . " (p. IV-5)

Although an effort was made to correct for these (and other) shortcomings, weaknesses of this magnitude have to call into question the validity of the final results of the study.

Second, like the Winfrey study, the scope of this "Size and Weight" study exceeds anything that has been attempted in Canada. In particular, there are a broad range of technical supplements used to

support the main study: topics range from a detailed analysis of payloads under various truck size and weight limits, a special analysis of "fuel effects", and so on. Further, the scope is broader in terms of the concept of impacts resulting from alternative weight and dimensions policies -- that is, while truck operating costs and highway costs form a major component of the final estimates, the cost of diverting freight to/from rail, the cost of accidents and some qualitative consideration of other impacts (air quality, noise, urban truck routes) are also considered.

Finally, there is a greater degree of sophistication evident in this study in comparison to Canadian research in the way the analysis handles the issue of distributing future freight flows across truck types. The mechanism used to "drive" the analysis is the development of truck operating costs under various regulatory scenarios. These changes in costs shift freight in three ways: shifts in commodity movements among different configuration types and highway systems; shifts in the distribution of truck traffic by GVW; and inter-modal shifts. The success of this method is not being judged here. The significant point is that the "Size and Weight" study uses a more elaborate procedure to handle a difficult problem -- one that is usually handled by some "gross" assumption in Canadian research. Whether this approach produces better estimates of truck activity under different regulatory policies is not known.

1985 U.S. "Longer Combination Vehicles" Study

As for the latest research from the United States, only the main report was available at the time this paper was prepared. (23) (A working paper on methodology is listed in the appendix to the main report, but as of April 1986, had not yet been released.)

From the main report, which is only a summary of the research, there are several points of interest. First, the basic methodology followed from previous American research in the sense that the primary concept of benefits was the lower unit cost of larger trucks in comparison to smaller trucks. One factor that added considerably to the degree of realism in this study is that the policy options being considered extended the use of certain vehicle types already in use in parts of the country, with the result that the analysts were able to use realistic data on the operating characteristics of these vehicles (i.e., both cost and use characteristics). Second, the possibility that American research has a much broader scope than Canadian research is reconfirmed in the listing of the 17 background reports (any one of which would constitute a major undertaking in Canada). For example, studies such as "Carriers and Shippers Use And Anticipated Use of Doubles and Triple Trailers" or "Rail Industry Competitiveness," to name just two of the 17, have never been attempted in Canada. Third, the fact that American researchers face comparable or worse data problems than their Canadian counterparts also seems to be reconfirmed -- not because there is much discussion of problems in the main report, but rather because the report refers to the 1977 TIUS as one of its main sources.

1980 U.K. "Higher Gross Weight Goods Vehicles" Study

The object of this study was to "examine possible consequences of a change in permitted gross weights" in a manner which would "contribute" to the assessment of the relative merits of a range of regulatory options. (24) The analysis focused on attempting to quantify the change in truck operating costs and the change in road damage factors which would result from the adoption of one of four relaxed weight limit scenarios in place of the base case (i.e., current) weight regulations. The road damage effect was measured in terms of "Standard Axle Damage Units", with no attempt made to transform this measure into monetary units. Effects on "bridges, road safety, traffic and the environment" were not considered.

The methodology was similar to that found in North American studies -- at least in broad outline. The first step was an estimation of the number and types of large (4+ axle) trucks which would be used to handle a fixed (1977) quantity and pattern of freight movement under each of the scenarios (including the base case). These estimates were made for both the "short" (up to 5 years) and "long" (more than 5 years) term. The second step was an estimation of the total annual operating cost of fleets estimated under each scenario and a calculation of the differences in total operating costs from the base case scenario.

In more detail, the estimate of fleets under each scenario was made in the following manner: (i) nine different tractor-semi-trailer options were defined (including the current one) by allowable axle and GVW limits, dimensional limits, unladen weight, weight and volume payload capacities, and other pertinent physical and performance characteristics; (ii) 33 truck operators were asked to specify how many of which of the nine vehicle options -- or their "draw-bar configurations" (i.e.,

truck-trailer) equivalents -- did they use under the base case scenario and would they expect to use under each of the four scenarios -- for both the short and long term, assuming no change in the amount of freight that each handled; (iii) referencing national commodity flow and on-road truck survey data, coupled with an estimate of the populations of maximum weight trucks operating in the system (as of 1977), the results of the interviews were "grossed-up" to provide an estimate of the system-wide fleet size and mix of 4+ axle units (short and long term) which could be expected to result from each of the weight limit scenarios.

In the second step, a critical assumption was made that many of the use characteristics of trucks remained at 1977 levels under each of the scenarios (annual mileage, proportion of empty miles, trip lengths). Given this, 1979 truck operating costs from a standard cost model were used to develop total operating costs for each truck type, total cost for the entire fleet (under each scenario), and the difference in total cost from the base case.

The study also identified and discussed various indirect effects of relaxed weight regulations such as: (i) reducing inefficient use of maritime containers, some of which were having to be loaded/unloaded at dockside or carried light for all of an extra-territorial trip because of weight limitations in the U.K. relative to other trading partners; (ii) similar reductions in inefficiencies with RO-RO operations; (iii) potential rate and other cost savings which might result from the adoption of greater consignment sizes. On other potential effects the study notes that (i) there appeared to be little likelihood of important mode shifts occurring in response to relaxing weight regulations; (ii) relaxed regulations could not be expected to generate new traffic flows; (iii) truck manufacturers might benefit from "harmonized regulations" by allowing them to "rationalize their designs and perhaps to compete more effectively in home and export markets".

This British research is similar to much of the Canadian research in the sense that it starts from the position that larger trucks can handle freight at a lower unit cost than smaller trucks and ends by demonstrating that there are reductions in freight costs (benefits) when a fixed amount of freight is redistributed across a fleet of larger trucks. The only thing that differs from most Canadian research is the method used to determine the number of large trucks resulting from increased weight and dimension limits (i.e., surveying operators). Given that any truck operator offered the opportunity of using larger more efficient trucks would probably do so -- particularly given the assurance that total freight volumes would not decrease -- this analysis in effect was designed to be a self-fulfilling prophecy: relaxed regulatory regimes and the consequent use of larger trucks will lead to reduced operating costs per unit of freight handled.

5. DEFICIENCIES IN PREVIOUS ANALYSIS

As this review of Canadian (and to some extent, non-Canadian) research has indicated, there are many deficiencies. The following are of particular importance:

The Narrow Characterization of Benefits

Possibly the most serious deficiency in most cases is the concept of benefits as a reduction in truck operating costs. As discussed, the efficiency of the trucking system involves more than just the ratio of truck costs to trucking output. Even if it is accepted that changes in truck operating costs are a good first approximation of benefits, there are problems in the way this measure is being used: (i) often, the assumption is made that the reduction in truck operating cost is the decrease in the potential cost reductions per unit of shipment weight (i.e., instead of developing empirical measures for the utilization rate of large trucks and ignoring density characteristics of freight); (ii) implicitly, it is often assumed that the relevant truck operating costs are linehaul costs only with no consideration given to either how linehaul operations might change (e.g., a change in the proportion of empty miles or even inter-city versus urban-area miles) or how other aspects of trucking might change (terminal operations, switching-yards, P & D operations, etc.); (iii) with respect to for-hire truck operations, there has been little research (in Canada) as to the degree to which truck cost reductions (whether just linehaul, or total) are passed through to the shipper.

A Failure to Analyze Past and Current Truck Characteristics

Canadian research that has estimated the benefits associated with a regulatory change has typically started with the development of various regulatory alternatives. But to date, it has been difficult to properly characterize current fleets -- let alone fleets under some other scenario. Specifically, it is difficult to find research which documents the number of large trucks by registered weight, by

body style, by actual operating weights, by configuration characteristics, by annual usage (kilometers, tonne-kilometers, etc.), by commodity specialization, by class (for-hire, private, farm, etc.). This deficiency is not, apparently, unique to Canada.

One of the reasons for this difficulty -- and the associated lack of understanding about the trucks using the roads -- is the problem of data availability in Canada: vehicle registration data from 12 different jurisdictions is almost impossible to aggregate or, in some case, even acquire; and, road-side survey data from these same 12 jurisdictions is only available on occasion, is collected in a variety of manners, and, in any case, is difficult to reconcile with total truck activity (i.e., each survey point has some unique physical and temporal attributes that cannot be totally related to all other possible observation points on the road network).

It is understandable, then, that there has been little research in Canada into the temporal aspects of fleet changes. That is, the understanding of how fleets change over time, both as a result of changes in weight and dimension regulations and, of equal importance, as a result of other forces, is very limited. This is critical as most research is forced to make a simplistic assumption such as "the regulatory change will work its way through the fleet in five years." Preliminary data now being developed suggests that this type of assumption is an extreme over-simplification.

The Paucity of "Cross-Sectional" or Comparative Research

The literature on the effects of weight and dimension regulations using cross-sectional techniques (i.e., comparing truck fleets, payloads, operating costs, etc. in different provinces, regions, countries, with different regulations) is sparse. Given the importance of the potential impacts of regulatory change -- trucking is the largest freight mode in Canada -- more extensive search of this type could have assisted many of the analytical efforts reviewed here. Much of the research done in Canada seems to have been done in ignorance of research efforts elsewhere; and little research has been done where the main purpose was to compare the fleets of different jurisdictions.

The Inability to Forecast

Forecasting capabilities are not well developed (freight forecasts generally use some other forecast as the primary independent variable) and rarely, if ever, is any effort spent on verifying the predictions.

With respect to the first point, it is possible to check the accuracy of one of the Canadian studies. Specifically, the 1973 Alberta study made forecasts that can be fairly closely checked with the 1978 Western Canada O/D survey (the 1973 study forecast or five years into the future). The following, in millions of ton-miles, shows the results of this check:

	Forecast	Annual (1978)
All traffic	44.6	113.3
Intraprovincial traffic	18.4	80.0

The fact that the study went on to multiply its results by an estimated 2.56 to account for trucks missed in the survey, and to further multiply the results by an estimated 51 to account for the weeks not included, and to further multiply the results by estimated costs for a vaguely defined mix of truck types five years in the future only compounded the possible errors.

"Simplistic" Scenario Definitions

To date, most Canadian research has only attempted to deal with "simple" regulatory changes -- an increase in allowable GVW's, an increase in allowable axle weights. In point of fact, weight and dimension regulations and changes in these regulations over the past decades (and presumably into the future) are far more complex than this. With the regulatory changes that have been made in Canada, most of the research effort (respecting the "benefits") has tended to focus on weight issues only; many issues necessary to make these increases effective have been ignored: centre of gravity concerns, load distribution, suspension systems, etc.

A classic example of how research can become divorced from the complexities of the real world is the recent introduction of 48-foot semitrailers in Canada (or 14.65-metres as the regulations permit). Some initial estimates assumed that the increased cube in these semitrailers would be fully utilized. In actual trucking operations, however, it was found that past practices that had managed to load a certain number of pallets into 45-foot semitrailers had some difficulty in squeezing an additional pallet into the three extra feet of trailer space made available. None of the "scenario definitions" seen to this point in Canadian research develops this type of detail in estimating benefits.

Politics
Canadian (and probably other) research suffers because of the political necessity of producing one hard quantitative estimate of the benefits of changing regulations. This results in studies where most of the effort goes into making (or justifying) assumptions to develop procedures capable of producing a number, rather than studies where most of the effort goes into an attempt at understanding what is actually happening.

6. CURRENT RESEARCH

Limitations and deficiencies in previous Canadian research -- and to the extent that has been ascertained, in much of the work conducted in other countries -- has given rise to a less ambitious approach in current Canadian research. An ongoing project by the authors, has defined as its major purpose:

> "... to develop a detailed understanding of how weight and dimension regulations affect truck types, the trucking industry, shippers, and the public."

The implication of this statement, and indeed the ultimate criticism of previous Canadian research is obvious: Canada has pursued a course of relaxing regulations with little practical appreciation for the actual size or the nature of the effects -- all of which together establish the benefits of regulatory change.

Four specific objectives have been defined in this work. The first is to develop a comprehensive understanding of the implications of vehicle weight and dimension regulations in terms of the range of feasible truck types they permit -- recognizing regional/route differences, commodity/hauling situations differences, seasonal differences, and differences associated with "special permitting" considerations.

While developing an understanding of feasible truck types may seem a minor problem in the scheme of things -- and little more than a pursuit of the obvious -- the reality is that prior to this work there was no comprehensive understanding of the Canadian regulations, let alone their implications for important details which either determine or influence the types of vehicles which can feasibly be operated. The first working paper developed in this research (2) presents a detailed analysis of weight and dimension regulations and their implications on the load-carrying capabilities of the most common large-truck combinations -- as a function of axle spacing, spread and tire specifications. The paper also provides the basis for determining the feasibility of operating any other possible vehicle combination and its weight-operating limitations, in terms of both individual axle loads and GVW, by season and road class.

The second objective is to develop a clear understanding of actual -- as distinct from feasible -- truck types and truck fleets which result from different regulatory regimes and changes in those regimes.

The Canadian regulatory environment provides a living laboratory in which both the cross-sectional and temporal impact of regulations on truck fleets can be conducted. This portion of the research is relying on the analysis of vehicle registration data and on-road truck survey data. Neither of these types of data bases are particularly well-developed (as discussed elsewhere) (25). Nonetheless, good progress has been made in furthering the understanding of fleet characteristics as a function of detailed regulatory considerations; additional work of this type is currently underway (some of which is or will be reported in (1)(26)(27)).

The third objective is to analyze both the potential and actual productivity/operational implications of various weight and dimension regimes.

The potential (i.e., "theoretical" or "achievable") component of this analysis will study payload-handling capabilities (by freight type), annual utilization rates, cost structure and energy use of a selected number (30 to 50) of feasible and actual truck types operating on Canadian highways. This step of the analysis will involve, for each truck type and weight and dimension limit scenario as appropriate: (i) determination of tare weights, cubic payload and weight payload capacities; (ii) development of a range of typical, feasible, operating assumptions, including those relating to payload handling; (iii) calculation of appropriate feasible ranges of utilization for different vehicle types handling different commodities; (iv) development of appropriate input cost data; (v) development of resultant potential per tonne and per tonne-kilometre costs. Particular attention will be paid to the implications of commodity-specific characteristics on the productivity potential of the selected truck types under analysis. Of particular interest in this regard is the cube-out rather than weigh-out characteristic of many commodities

when handled in the feasible and actual truck types in use.

Another component of the analysis will focus on developing a sound understanding of actual (as compared to potential) payloads, operating conditions, utilization rates, and cost experiences, based on an interview program directed at some 30 to 50 carriers representing a range of regional, operating and commodity haul situations. Analysis of existing on-road survey data and shipment size data will also be carried out to improve the knowledge of actual payload experience under different regulatory environments.

The fourth objective is to analyze evidence of "flow-through" effects of differences or changes in weight and dimension regulations on the shipping public.

Information will be obtained from interviews of both shippers and carriers. The interviews will be directed at providing an assessment of representative cases of the following types of considerations: (i) whether the significant relaxation of regulations in the Prairie region and in (some parts of) Atlantic Canada affected shipment sizes or shipping patterns; (ii) whether these changes resulted in new weight categories in the tariffs; (iii) whether changes in weight and dimension regulations affected shipper decisions respecting the use of for-hire versus private truck operations, or truck versus rail versus intermodal services; and (iv) whether, and to what extent, equipment-specific features unique to particular weight and dimension regulatory regimes (e.g., "pup" load charges) appear in the different truck tariffs.

7. COMMENTARY

This paper has been critical of past research efforts in Canada. It has to be emphasized that the main reason for this detailed review and critique is the belief that there has been a general failure to recognize that the "benefit side" of weight and dimension regulations is as complex as the cost side. The search for optimal regulations will require extensive work to clarify the linkage between the regulations, trucks, trucking operations, and transportation efficiency in general.

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