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Project Summary Report 2122-S
Project 0-2122: Synthesis Study of the Effects of Overweight/Oversized Trucks

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PROJECT SUMMARY REPORT

Effects of Truck Size and Weights on Highway Infrastructure and Operations

To facilitate cross-border traffic, the North American Free Trade Agreement (NAFTA) calls for harmonization of truck standards among the trade partners. Combined with the desire of U.S. industry to reduce freight costs, this aspect of NAFTA has stimulated interest in how liberalization of truck size and weight limits in the U.S. would affect highway infrastructure and safety.

What We Did...

This report distills the findings from the relevant literature, to which a major recent addition was the Comprehensive Truck Size and Weight Study prepared by the U.S. Department of Transportation (2000).

Truck Size and Weight Restrictions in Texas

The federal government limits vehicle weights on Interstate highways to a maximum of 20,000 lb for a single axle and 34,000 lb for a tandem axle. Vehicles on Interstate highways must also conform to the Federal Bridge Formula (FBF), which is designed to protect bridges from catastrophic overloads. The bridge formula restricts the weight of each of a vehicle's axle groupings and keeps the gross vehicle weight to 80,000 lb.

States can supersede these limits if they can show that their regulation would have allowed higher weights before the federal limits came into being. Texas is not well positioned to claim these "grandfather" rights and has not attempted to do so. Moreover, unlike some states, Texas has adopted the federal limits as the general weight limits off the Interstate system as well.

On about two-fifths of the extensive network of farm-to- market roads in Texas, gross vehicle weight is limited to 58,420 lb, the standard to which these roads were built decades ago. Both on and off the farm-to-market network, many bridges in Texas are load restricted, including some 4,000 that were built to standards of less than 58,420 lb.

For travel off Interstate highways, operators of trucks in Texas can obtain an annual permit that grants an additional 5 percent gross weight and 10 percent axle weight. For most trucks with the permit, the maximum legal gross weight becomes 84,000 lb, effectively exempting them even on roads and bridges with load postings.

Texas restricts the length of semitrailers to a maximum of 59 feet and places no limits on the overall length of tractor-semitrailer combinations. Notwithstanding a ban on triple trailers, the vehicle-length limits in Texas are relatively liberal by U.S. standards. They are less of an issue in Texas than the limits on weight.

Reforms to Truck Size and Weight Limits

The proposals for truck size and weight liberalization that have received the most attention in the research literature would encourage a switch from the dominant type of heavy truck, the five-axle tractor semitrailer, to trucks that have higher payloads and additional axles. An example is the elimination of the Federal Bridge Formula's 80,000 lb cap on gross vehicle weight. Removal of the cap would allow minimal or no increase in the gross weight of a five-axle tractor semitrailer, while allowing vehicles with additional axles to operate substantially above 80,000 lb. For typical short-twin trailers, for example, the bridge formula allows 99,500 lb with seven axles, 104,500 lb with eight axles, and 110,000 lb with nine axles.

The Comprehensive Truck Size and Weight Study considered three scenarios for truck size and weight liberalization:

The *North American Trade Scenario* would allow heavier tridem axles, up to either 44,000 or 51,000 lb, to facilitate trade between the U.S. and its NAFTA partners. On U.S. highways, this reform would introduce the eight-axle B-train combinations used in Canada, and would increase the use of six-axle combinations, which are currently much more common in Canada and particularly in Mexico.

The *Longer Combination Vehicles Nationwide Scenario* would establish a national network over which these vehicles could operate. Longer combination vehicles (LCVs) are multi-trailer combinations that operate at over 80,000 lb; they include Rocky Mountain Doubles, Turnpike Doubles, and triple trailer combinations. Twenty-one states (not including Texas) allow at least some types of LCVs, and some eastern states allow them only on their turnpike facilities. In this scenario, LCVs of each type would have defined weight limits—for example, 120,000 lb for a seven-axle Rocky Mountain Double.

The *Triples Nationwide Scenario* would establish a national network for seven-axle triple combinations weighing up to 132,000 lb.

What We Found...

Estimated Effects on Pavements

The estimates in the Comprehensive Truck Size and Weight Study indicate that the liberalizations modeled would reduce pavement costs—by 1.6 percent in the North American trade scenario and by 1.2 percent in the LCV scenario. In the triples scenario, the results indicate virtually no change in pavement costs (a reduction of only 0.2 percent).

In other studies, the findings suggest that similar liberalizations would leave pavement costs almost unchanged or slightly lower. For the elimination of the bridge formula's cap, the Transportation Research Board (1990) estimated an increase in annual pavement costs of a mere $10 million at 1988 prices. Hewitt et al. (1999) simulated the effect of restricting gross weights to 80,000 lb in Montana, which currently allows gross weights of up to 126,000 lb for vehicles that comply with the bridge formula. The scenario was thus equivalent to reinstatement of the bridge formula cap, or the opposite of what the Transportation Research Board simulated. The results indicated an increase in pavement costs on Montana highways of 1.2 percent.

There are two fundamental reasons why switching to a heavier truck with additional axles can leave pavement damage about the same or slightly reduced. First, allowing heavier trucks increases the payload per truck, so fewer trips are required to achieve the same freight task. The resulting reduction in vehicle miles of travel means less pavement damage. Second, the heavier trucks distribute their weight over a larger number of axles, as compared with the trucks they replace. Because pavement damage increases sharply with axle weight, the reduced weight per axle of the heavier trucks again means less pavement damage. An approximation derived from extensive tests conducted in the 1950s suggests that pavement damage increases exponentially with axle weight to a power of four—the so-called "fourth power" rule. This means, for example, that an increase in axle weight of 10 percent will increase pavement damage by about 46 percent.

On the other hand, adding more payload to a given truck will normally increase pavement damage. Hence, a liberalization of weight limits that does not encourage a switch to more-axled trucks can have substantial pavement costs. An example is the "2060" permit for overweight trucks in Texas, which has not altered industry reliance on five-axle tractor semitrailers, but has allowed these vehicles additional weight. The costs of pavement damage resulting from the permit depend very much on where the trucks travel, for which detailed data are lacking. In the worst case, a truck travels exclusively on roads designed to a 58,420 lb standard and, without a permit, would operate at that weight to conform to load postings. By allowing such a vehicle to travel at 84,000 lb, the permit would increase the pavement damage the vehicle causes by roughly $50,000 per year. Moreover, real-world experience suggests that this worst-case scenario prevails to an extent that confirms the permit's sizeable impact on pavement costs (Luskin et al. 2000).

A fair amount of uncertainty surrounds the relationship between truck weight and pavement damage. Although an increase in axle weight causes a more-than-proportional increase in pavement damage, various estimates of this effect have diverged significantly from the fourth-power rule. In addition, because the effects of axle spacing on pavement damage are complex, the evidence on the relative performance of tandem and tridem axles is not clear-cut.

Estimated Effects on Bridges

Although additional axles on a truck can substantially reduce pavement damage, the stress to bridges depends more on the truck's total load than on the number of axles. For this reason, increases to truck weight limits can create large costs for bridges, even when they encourage additional axles.

For bridges, the principal cost associated with heavier trucks lies in ensuring that the bridge can accommodate the trucks without collapsing. The Comprehensive Truck Size and Weight Study estimated the costs of

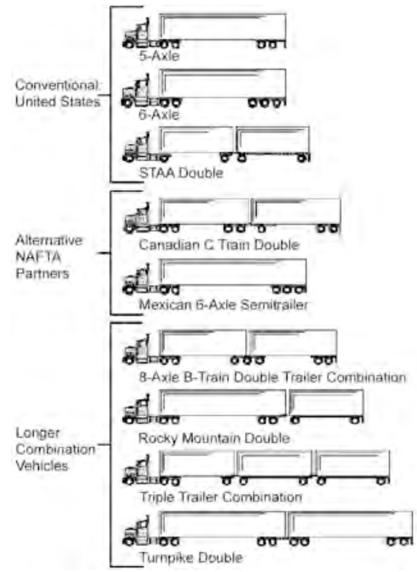

Figure 1. Alternative Combination Truck Configurations

truck size and weight reforms on the assumption that bridges that become safety-deficient under the new weight limits will need to be replaced. As the study notes, this assumption probably overstates bridge costs because some bridges could be strengthened rather than replaced, while others could be made off-limits to the damaging vehicles. The estimated increases in bridge costs were large: 10 percent in the triple-trailer network scenario, 34 percent in the LCV network scenario, and up to 42 percent in the North American Trade scenario.

Weissmann and Harrison (1998a, 1998b) estimated the bridge costs for another NAFTA-related scenario, one in which types of heavy trucks that are common in Mexico and Canada are allowed on U.S. highways. Bridges that these trucks would render safety-deficient would, in their analysis, be replaced. The Mexican truck was a 107,000 lb tractor-semitrailer with six axles; the Canadian truck was a 128,000 lb "C-train" short double. The authors estimated that, in Texas alone, the introduction of the Canadian-configured truck would require $7.7 billion in expenditures on bridge replacement, and that the Mexican-configured truck would require about $6.6 billion. As the Comprehensive Truck Size and Weight Study also found, the largest cost of bridge replacement turned out to be associated with the disruption to traffic while the work is underway. Of the total estimated cost for accommodating the Mexican-configured truck, about 85 percent consisted of time losses to motorists during reconstruction.

Effects on Traffic Patterns

Because truck size and weight reforms affect pavements and bridges only to the extent that they alter traffic patterns, predicting the various effects on traffic patterns is a major challenge. Each of the attempts we reviewed featured some omission or simplification that could be significant.

For most reforms, the most important traffic effects are the changes in choices of type of truck. A reform may allow the use of heavier trucks, but to what extent will shippers actually use them? The switch to the heavier trucks will not be fully realized immediately upon introduction of the reform, given the large amounts of sunk capital in existing trucks and related infrastructure.

Even in the long run, the extent of switching will be limited by service quality factors. For example, a potential consequence of using larger trucks is that deliveries become less frequent, with attendant increases in inventories and disruptions to business operations. Alternatively, service frequency can be maintained through consolidation of less-than-truckload shipments, although this has costs, too. The potential costs of consolidation include more circuitous truck routes, additional resources for coordinating shipments, and double handling of freight. The Comprehensive Truck Size and Weight Study had a relatively elaborate framework for estimating truck-to-truck switching, but even this framework did not fully come to grips with these complexities. The assumption was that the use of heavier trucks will reduce service frequency and that the resulting costs are solely in the form of additional inventories.

Service quality considerations present similar challenges for modeling choices of transportation mode. Choices between trucking and rail freight services (or rail combined with road) generally present a tradeoff between price and service quality. Rail freight is generally cheaper, but trucking has advantages in flexibility, speed, and often reliability. It is difficult to quantify the service levels provided by each mode and the values shippers assign to service attributes.

Modal switching would not be the only source of increase in the volume of truck freight when truck size and weight regulations are eased. A state that increases its truck size and weight limits could attract more industry, which in turn would place more truck freight on its highways. In addition, when truck freight services become cheaper, producers may reduce their inventories or consolidate their plants and warehouses. The producers thereby increase their reliance on freight services, but reduce other costs by even more. These sorts of responses are extremely difficult to estimate, and very few of the truck size and weight studies have attempted to do so. More research in this area is needed.

The Comprehensive Truck Size and Weight Study included in its simulations the diversion of freight from rail to trucking, but not the other increases in truck freight that could result from size and weight liberalization. For each liberalization scenario, the study estimated the net effect on the total vehicle miles of trucks having more than two axles. The estimated effect was negative in each case because the increase in vehicle miles resulting from modal substitution was outweighed by the decrease in vehicle miles resulting from larger payloads per truck. The estimated reductions were more than 10 percent for the North American Trade scenario and more than 20 percent for the other scenarios. Other studies, including one conducted by the Transportation Research Board (1990), have also predicted reductions in truck traffic brought about through increased limits on truck size and weight.

What We Found...

Effects on Safety

If truck size and weight liberalizations reduce truck traffic, as several studies have predicted, they may also reduce the number of accidents involving trucks. Moreover, even without any change in truck vehicle miles, the literature on truck safety does not allow firm conclusions about the net effects of truck size and weight limits. Although heavier and larger trucks often have safety drawbacks, changes in vehicle and roadway design and in driver performance can compensate to a large degree.

For example, while multi-trailer trucks are dynamically less stable than five-axle tractor semitrailers—and hence more prone to rollover during evasive maneuvers at high speed—suitable connections between the trailers can do much to add stability. (B-train and C-dolly connections effectively eliminate an articulation point and, hence, are more stable than the more widely used A-dollies.)

Better selection and training of drivers, which has contributed to past declines in commercial trucks accidents, can counteract the potential safety risks of larger and heavier trucks. An argument can also be made that people tend to drive more cautiously in dangerous situations—the "risk compensation" hypothesis. So even when a heavier or larger truck has features that, other things being equal, would increase the rate of accidents, the driver response to this situation may offset much of the added risk. However, reliable evidence on risk compensation behavior among drivers is lacking.

Many studies have attempted to estimate the differences in crash rates among classes of heavy trucks, often with a focus on double-trailer combinations and, in particular, on longer-combination vehicles. Depending on the study, the LCVs or double-trailer combinations may have crash rates that are slightly lower, slightly higher, or about the same as those for other heavy trucks. The lack of a clear picture partly reflects the severe limitations of available data on the crash rates of different classes of heavy vehicles (see Scopatz 2000 and Mingo, Esterlitz, and Mingo 1991).

The Researchers Recommend...

- Additional research on the costs that heavier trucks create for bridges
- Collection of better data on highway accidents involving heavy trucks.

For More Details ...

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The research is documented in the following report:
Report 2122-1, *Effects of Truck Size and Weights on Highway Infrastructure and Operations: A Synthesis Report,* Draft June 2001

To obtain a copy of the report, contact: CTR Library, Center for Transportation Research, phone: (512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status
June 2001

The information provided in this synthesis will be of value to TxDOT administrators and the Transportation Commission as alternative truck size and load limits and proposed modifications to permit requirements are evaluated. Changes in truck standards can be initiated only through legislative action.

For more information, please contact Paul E. Krugler, P.E., Director, Research and Technology Implementation Office, (512) 465-7403 or email: pkrugle@dot.state.tx.us.

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