Science and Policy in the Economic Assessment of Transport Regulations

WILLIAM G. WATERS, II

Science and policy

Science is the institutionalized activity of expanding knowledge by investigation, research, and debate. This scientific activity places considerable emphasis on reviewing available knowledge, devising experiments or conducting investigations to shed light on the questions of interest, and publishing or submitting the analysis for peer review. Although we often have "hunches" or hypotheses to investigate, ultimately there is commitment to seeking the truth, that is, accepting whatever one finds and communicating that. Science and research place emphasis on the use of logic and empirical evidence in arriving at a position. The foregoing description could be qualified in many respects but it will provide a point of contrast.

Policy refers to the development of rules, regulations, or other actions by government agencies or representatives, devised in response to perceived needs of the public. The public may encompass broad groups in society or policy may be aimed at helping particular groups if there is broad consensus supporting such a policy. The analysis and decision-making leading to policy often emerge in a highly charged

Notes will be found on pages 70–71.

political atmosphere where perceptions of problems and solutions may be more important than objective descriptions and factual analysis.

There is more to the process of science and policy-making, including questions of principle versus practice. But, these two cryptic descriptions are sufficient to raise a few questions.[1]

Potential conflicts between science and policy

Although one would expect that knowledge, fact-finding, and analysis would be a key part of formulating public policy, the decision-making environment is not always compatible with the requirements for scientific analysis. For one thing, policy-making typically functions on a tight time table: policies must be devised, sometimes on short notice. Governments *will* make decisions, with or without good advice. In contrast, science (meaning conceptual and empirical analysis) cannot always produce definitive answers as learned people may disagree and different empirical analyses may produce different results. Science and knowledge progress by confronting and comparing different approaches. There is no tight time table to invoke closure on scientific debate. It is important that existing knowledge be codified and summarized to help policy makers but, at times, the state of the science (or that of the scientific advisors) may not be able to provide the definitive guidance that is sought.

Projects and policies are viewed through different lenses: academic researchers, politicians, and civil servants have different perspectives and professional backgrounds. This can affect both the objectives pursued and the interpretation of costs and benefits. Even within the civil service, there are different perspectives, which reflect the type of department they represent. Treasury Board staff tend to have a different perspective on proposed projects or policies than the view taken by those in the operating agencies putting the policy proposals forward (Boardman, Vining, and Waters, 1993).

There are other characteristics of the political environment of government policy making that are important to recognize. One is that governments may favour groups or regions or industries that are a political priority. The resultant objectives and actions might not stand up to objective analysis based on broader goals; that is, short-term political priorities can differ from long-term goals and the means to achieve them.

A second important characteristic of the political process is that perceptions and popular opinion matter a great deal. Politicians respond to, and mirror, the public mood. It is common for people to hold beliefs that are inconsistent with the facts. The average person does not engage in scientific inquiry to evaluate the information coming from the media. People form opinions and politicians survive by reading these moods and designing policies that appeal to constituents. The

key point is that perceptions are (or, at least, can be) reality in politics. These can drive decisions and they can be in conflict with what careful and scientific investigation would reveal.

A third characteristic of the process of policy making, which can be important at times, is secrecy. A fundamental characteristic of good research and thorough investigation is the regular revelation of progress and conclusions, opening them to criticism. But, in the hypercritical world of democratic politics, often it is necessary to keep options and investigations secret because opponents of government have an interest in anything that can be seized upon to criticize the government of the day.

Related to this is the problem of acknowledging errors. While it is embarrassing to researchers to realize that some of their hypotheses were wrong or evidence misinterpreted, there is a common acceptance that knowledge advances by detecting errors and redirecting effort. In the world of politics, however, error may be seized upon as a sign of weakness or poor judgement by the government. As a result, there is great reluctance to admit error. Often governments must continue to pursue a policy, even when they realize that it is a mistake, because there would be broader strategic costs if they were to admit error.

The implication of the latter two characteristics is that it is all the more important to get policies right the first time.

The growing importance of risk assessment and regulation

Risk assessment and regulation is becoming more important for governments all the time. The reductions in government spending and accompanying decrease in staff in recent years has meant that government has less capacity to carry out the policies it would like. A reduction of direct expenditures or operations by government makes regulatory policies relatively more attractive. Regulations have the seeming attraction of directly targeting something the government wishes to achieve while the costs of implementing the policy are largely borne by those affected by the regulations rather than by the government. This is an attractive feature to a fiscally constrained government; however, it is seen as negative by economists and policy analysts because the government implementing a regulation may be oblivious to—and normally does not bear—the costs imposed on society of adhering to the regulation.

Secondly, the increase in risk assessment and regulation is a paradox of modern wealthy societies. We live in an age when the traditional scourges of human kind—the "four horsemen of the apocalypse"—are largely subdued for residents of wealthy countries. Nevertheless, many of us are quite preoccupied with risks and demanding more from governments on these issues. There are several reasons why this might be

the case. The primary one is wealth itself: having escaped the prospect of famine, pestilence, and so on, we enjoy life and are wealthy enough to worry about what would have been minor concerns in previous generations. There is also the argument that modern industry is producing more substances and at least some of them will have harmful effects upon us, given our long life expectancy. Further, our ability to conceive of, and investigate, potentially harmful effects is increasing. We can measure minute particles every more minutely.

For all these reasons, governments are finding risk analysis and regulatory policy of growing importance.

Science and public opinion polling

The Canadian government, and those of the Provinces, place great emphasis on polling to find out what people's feelings or perceptions are about problems and possible policies and, hence, what issues are perceived as important and what policies are politically feasible. While *realpolitik* cannot be ignored, there is a big difference between establishing policy on the basis of widely held beliefs or perceptions and constructing policy on the basis of facts and knowledge. Note that we can be very scientific in gauging and measuring public opinion but this is not the same as basing policy on scientific fact about the problem requiring a policy response.

Some fear that recently there may be a reduced commitment in government to the pursuit of real knowledge and analysis and, instead, officials are concentrating on collecting opinions of the public and of interest groups to guide policy. This includes engaging stakeholders in the formation of policy. Stakeholders might have objective analysis and evidence behind their position but they might also be acting from pure self-interest. Given the everyday pressures that face those on the policy front line, it is not hard to see that public acceptance of policies—whatever scientific validity may underlie their beliefs—could come to be an expedient and seemingly less risky approach to policy formation.

Implications

Civil servants are caught between the politician's desire for quick policies that respond to public perceptions and the academic and research communities' belief that careful, lengthy, and often expensive study is required to assess real policy needs accurately and weigh the cost and benefits of alternative policy actions. Some public issues and policy alternatives can be anticipated so that research and analysis can be carried out in advance and hence influence actual policies when they suddenly rise high on the political agenda. For long-term policy formulation, it should be possible to meld science and research with policy formula-

tion. This does not mean that it is an automatic or a smooth process. Knowledge comes with debate and disagreement along the way. It can be difficult to sort out disagreements among researchers. How does an administrator sort out which econometric equation and results are to be accepted? But time and at least some resources can be allocated to address such issues when the policy deadline is not urgent. But, often there is urgency and it is necessary to make policy decisions with or without consensus from the research community.

Evolution of economic evaluation of public policy

There is much experience with the economic evaluation of government projects and policies. These include the broad policy analysis of macroeconomic studies or aggregate industry/market studies in contrast to microeconomic studies of specific investment projects or policy proposals. A recent example of macro-studies in transportation would be D.A. Aschauer's empirical assessment of infrastructure spending and economic development (Aschauer 1989a, 1989b) and the extensive literature that followed his studies (see Gillen 1996 for a concise review of this literature). There are numerous examples of the empirical assessment of the impact of policies on specific industries or markets.

Microeconomic analysis in transportation has been used extensively. Cost-benefit analysis (CBA) has been used extensively since the 1950s[2] to evaluate infrastructure projects. CBA has also been used to evaluate regulatory policies but examples are fewer in number. Cost effectiveness analysis (CEA) has also been used extensively, especially in the field of transportation safety. The main difference between the two techniques is that CEA frameworks tend to be less comprehensive than CBA frameworks, which are supposed to include all benefits and costs "to whomsoever they may accrue," whereas CEA might focus only on one or two measures of effectiveness. The other important characteristic of CEA is that it does not put dollar values on the measure of effectiveness. For example, a CBA study of an improvement in transportation safety would require that a dollar value be placed on lives saved, injuries avoided, and so on, whereas a CEA study would merely rank different policies in terms of the cost-effectiveness rating such as cost per life saved or cost per accident avoided. This avoids the controversy of valuing intangibles yet still is useful for prioritizing and rationing a scarce budget. However, while CEA is useful for prioritizing within a department, unlike CBA it is not as useful for making comparisons across different measures of outcome.

In terms of the economic evaluation of regulatory policies, there are three main areas of application (which may overlap):

(1) traditional economic regulation (price regulation, controlling entry into, or exit out of, an industry, licensing, consumer protection);

(2) transportation safety (this can include vehicles and operations, safety, infrastructure standards, traffic control;

(3) environmental regulations (these include air-emission standards, both local and global warming, ground contamination, energy, and human dimensions such as noise and health impacts).

Economic evaluation of risk and regulation in transportation

An electronic scan on a number of key words and phrases (cost benefit, risk, environment, transportation, etc.) produced a stack of abstracts many centimetres thick and an electronic search of the literature produces the iceberg's tip of what is actually in the public domain. A short and arbitrary list of the topics revealed is shown in Appendix 1. The list illustrates the diversity of topics that exist.

To draw some lessons from the application of CBA and CEA to the regulation of transport risk, it is instructive to focus on a few specific issues that have been studied a great deal: (1) the research and evidence on the American regulations on fuel economy for automobiles; (2) a policy initiated for energy reasons but subsequently justified for safety reasons (the American 55-mph speed limit); and (3) automotive air bags.

Fuel-economy regulations and their effects

One well-publicized and extensively studied policy has been the American attempt to increase the fuel economy of automobiles through regulations. This has been a long-term policy, not subject to reversals in direction. This is a useful case study with some lessons about regulations and economic evaluations of their effects.

The policy emerged following the fuel "crises" of the 1970s, although even prior to this there were various calls for government intervention to reduce fuel consumption. There was (and is) wide belief that the true social-opportunity costs of petroleum are understated and, hence, fuel is consumed at higher than optimal rates. The arguments include:

(1) the United States is a monopsony or dominant buyer (the converse of a monopoly supplier), which leads to prices below actual marginal cost;

(2) a substantial portion of American defence expenditures is aimed at keeping oil fields in the Middle-East secure and the costs of this protection should be included in the price of gasoline;

(3) oil markets are myopic or influenced by short-term political priorities of supplying nations and, hence, the current market price is below that which is sustainable over the long-run;

(4) much vehicle use is a deductible business expense and, hence, consumers are not paying the full price of fuel;

(5) environmental costs such as local and global air pollution costs are not internalized (Lave and Lave 1999: 262).

If true, gasoline is underpriced with the predictable consequence that larger quantities of gasoline are consumed than would be the case if the price were higher. In the long run, the problem is compounded as complementary decisions and investments are made in response to cheap fuel; for example, motorists would tend to buy less economical cars and use them more intensively, including, possibly, living in locations, and adopting life-styles, more dependent on cheap fuel. One solution that has been suggested

> would be to impose a tax to account for the externalities. Gasoline taxes, however, are unpopular. The CAFE [corporate average fuel economy] standards are thus an attractive alternative for politicians who find a gasoline tax politically inexpedient or who believe that regulation is a more equitable mechanism for reducing future demand. Although the CAFE regulation is more attractive to politicians, economists are quick to note that the cost of achieving the desired goal is likely to be higher with regulation than with a market approach, such as an externality tax. A market approach provides an incentive to change behaviour immediately while giving maximum flexibility to all parties to achieve the desired goals.
>
> A further difficulty is that Congress made a guess that doubling fuel economy was the right regulation. [Today] with oil prices below 1973 levels, after accounting for inflation, the CAFE standards specify fuel economy levels much higher than are demanded by consumers. (Lave and Lave 1999: 262–3)

There are at least two issues here. One is the choice of policy instrument, direct regulation or taxation. The second but related and more subtle issue is the long-term consequences of conflicting policy signals.

The debate between those advocating regulation and those advocating taxation (pricing) is not new. Rather, it is a long-standing conflict between economic advice and policy action. Economic arguments often identify pricing or taxation as a superior tool for responding to a misallocation of resources but it frequently encounters significant objections by policy makers. Some objections have a "scientific" basis; for

example, it is claimed that welfare economics arguments for taxation solutions do not take income distribution into account. However, it has also been noted frequently that the effects of income distribution often are exaggerated and quite possibly correctable. There is a deeper dislike of pricing mechanisms by the general public and hence by the politicians who mirror public moods, perhaps because the majority of people do not understand the subtlety of economic arguments. Concerning the CAFE regulations, A.M. Howitt and A. Altshuler (1999: 235) note that people seem to accept the notion that a few corporations can be bullied into achieving desired public-policy goals without the need of burdening the public at large via higher taxation. This may well be a plausible description of the policy environment that lay behind the fuel-economy initiatives but the economics is not sound. The costs of achieving the fuel-economy standards will be borne by the users, whether in gasoline prices or the prices of cars that they purchase. Popular perceptions and the conclusions from economic analysis are in conflict here.

There was also an on-going conflict between the broad imposed policy of increasing fuel economy and the eventual real decline in fuel prices. At first, the fact that fuel prices were not raised probably did not make much difference. The prospect of rationing and scarcity of gasoline supplies would imply a long-run shadow price of fuel above what motorists were paying at the time. But, over time, the feared fuel shortages did not materialize and motorists adjusted to the low fuel prices. Choosing a regulatory policy over taxation is not a "one-off" decision. The inconsistency between regulations and the price incentives to consumers hampered market performance, increasing costs as manufacturers struggled to meet standards inconsistent with personal preferences of consumers responding to relatively low fuel prices. Although more factors than fuel prices are involved, the rising popularity of light trucks and, now, sport utility vehicles are a manifestation of consumers purchasing the larger and less economical vehicles that they desired (trucks had lower fuel-economy standards). That is, over time inconsistencies or behavioural responses by consumers may undermine the costs and effectiveness of initial policies that were incomplete or inconsistent in their construction.

Finally, there is the appearance of side effects that were not recognized initially. In this example, there are trade-offs between policy goals. The goal of increasing fuel economy (whether by regulation or price mechanisms) sets forces into motion that alter the design of vehicles. In this case, increased fuel economy led to smaller and lighter vehicles. But, there is a significant correlation between the size of a vehicle and personal safety in crashes. Crandall and Graham (1989) esti-

mate that the down-sizing of cars to meet fuel-economy standards resulted in a 14 percent to 27 percent reduction in safety.[3]

In summary, the fuel-economy standards for automobiles are a worthy case study of the costs and effectiveness of policy actions even when those policies are consistent over a long period of time. They illustrate the importance of consistency between regulatory policies and pricing and taxation policies. Even if economists' arguments for pricing policies are rejected by policy makers, real complications and costs are likely to emerge if at least some reliance on pricing policies is not employed. This long-standing policy and its consequences are useful for illustrating how human and corporate behaviour can thwart or, at least, complicate intended policies and their costs. Similarly, it provides interesting examples of side effects whereby achieving one goal may conflict with other goals being pursued by other policies, that is, the emergence of "solution-caused problems" (Lave and Lave 1999: 287).

While economists are quick to invoke pricing and taxation as the recommended policy instrument, there are some compelling arguments for at least some role for technology-forcing regulations in the case of fuel economy. Even if automobile manufacturers thought that fuel prices might rise in the future, any individual manufacturer would be taking a high risk to begin to produce vehicles with much greater fuel economy. Government policy stabilized expectations about the future by calling for mandated economy standards. Although one can debate whether or not the standards set were appropriate, they did have the effect of keeping the playing field level so all manufacturers could compete under a consistent set of rules.[4]

The Regulation of Transportation Safety

Government involvement in transportation safety is decades old. There are many examples of economic analysis used to evaluate existing and prospective regulations; but there are also many cases where regulations persist contrary to economic criticism. Reviewing a couple examples of long-standing regulatory policies can shed light on the controversies that can arise around the economic analysis of transport safety.

Background on safety regulation

There are a mix of motives behind government involvement in transportation safety. Many regulations are a response to classic market failures, notably the problems of asymmetric information and externalities. Transport operations often produce situations where consumers may know little about the safety of transport operations but the suppliers know a great deal. Under these circumstances, buyers make decisions lacking full information and this could cause firms to produce goods

that are less safe than they should be or claim that operations are much safer than they really are. Market outcomes will not be efficient. The other market failure prominent in safety issues is externalities: users of the transportation system may impose costs on others that they do not take into account in making their decisions. Even if unsafe drivers were to weigh the risks incurred to themselves, they do not take into account the risks imposed on others. Both of these market failures are *potential* rationales for government intervention (*actual* justification if it is found that the benefits out-weigh the costs of intervention).

It is common for safety intervention to include elements of paternalism in the rationales, that is, to protect people from themselves. It can be difficult to separate paternalism from lack of information. If people are observed not taking advantage of safety equipment (e.g., seat belts), is this because they are inadequately informed and would use seat belts if they fully understood the probabilities of injury? Or, are they deemed to be exercising bad judgement and need to be protected from the folly of their own actions?

One of the intriguing but also frustrating characteristics of transport-safety regulation is that policies sometimes lead to behavioural adjustments by users that thwart the intended safety goals. In its extreme form, this is the "offsetting behaviour hypothesis," attributed to Peltzman (1975) but which has been noted and studied by many authors. An example may be a recent popular innovation to improve safety, the Antilock Braking System (ABS), which prevents wheel lock-up during heavy braking and thus enables drivers to have better control. (I ignore controversies over whether or not ABS brakes always lead to improvement; there are some circumstances where this is not true.) If drivers' behaviour were not altered by the presence of the brakes, we would see reductions in crashes, fewer pedestrians hit, and so on. But, what if the drivers modify their behaviour to take advantage of better braking? If drivers accurately understand the technical capabilities and wished to continue driving at the previous level of risk they faced, this would nullify the effects of the brake technology. The even more alarming scenario is that, if motorists overestimate the benefit of ABS brakes, they could end up having even worse safety records. This is a graphic illustration of the possibility of the off-setting behaviour hypothesis. "Society may be happy about the people with antilock brakes who can get to church on rainy days but not about those who use their new-found confidence to terrorize slower drivers" (Small 1999: 153).

There is a further complication with the possibility of behavioural adjustments in response to safety improvements. From the perspective of automobile safety, this means that policies are undermined by drivers' behaviour. On the other hand, from an economic perspective there

is still a benefit being realized. If drivers are accurately informed about the risks and how they are affected by a new regulation, the fact that drivers choose to drive faster or closer to one another indicates that they value the time saving or other benefit as more valuable to them than the intended safety benefit (Lave and Weber 1970). That is, a benefit is realized by motorists but they deem it more desirable to "consume" the safety benefit in some form other than safety. This is usually regarded as a failure by automobile-safety advocates but, so long as there are no externalities or other such problems (it is, however, plausible that these factors are at work in many safety concerns), then a CBA might conclude that the policy was worthwhile even if it was failing by its CEA test.

It is useful to review a couple of transport-safety issues that have been widely studied to see some examples of the complications that arise in trying to assess safety policies. These are speed-limit regulations, specifically the 55-mph speed-limit policy that was pursued for several years in the United States, and the more recent controversy over air bags.

Evaluation of the 55-mph speed limit

The 55-mph speed limit in the United States originated in response to the energy crisis of the early 1970s. By slowing down cars, fuel consumption would be reduced. The policy appeared to work although there were other factors at work, notably reductions in traffic as trips were cancelled due to possible fuel shortages and the recession that accompanied the rise in fuel prices.

As fuel shortages eased, the rationale for the policy shifted from energy conservation to safety: the 55-mph speed limit was accompanied by a substantial reduction in crashes and fatalities from 55,500 fatalities in 1973 to 46,400 in 1974 (National Research Council; cited in Lave and Lave 1999: 271). This seemed to confirm the popular view that "speed kills." But, closer analysis revealed that the issue is more complex than was popularly thought (Lave and Lave 1999). In the first few years, the reductions in fatalities could be explained by a number of factors including an already existing downward trend in the accident and fatality rate, and the reduction in travel due to the recession (and fuel shortages early in the period). Another factor was that the speed limit not only reduced the average speed but also reduced the variance of speeds on the road. The data from the early years were not sufficient to test this influence but subsequent studies have confirmed that the variance of speed of vehicles is an important factor, possibly more important than the speed limit. That is, abnormally slow drivers pose a threat just as abnormally fast drivers do.

The increase in speed limits in 1987 provided another opportunity to assess the impact of the speed-limit change. At first glance, it appeared to support the viewpoint that speed kills: fatalities did increase on the interstate highways following relaxation of those speed limits. However, further analysis showed that this was misleading. Fatalities did increase but traffic volumes jumped substantially on these higher-speed highways. That is, people were diverting from slower highways to the faster and normally safer interstate highways. Focusing on total fatalities in a state rather than just on fatalities on the interstate highways and correlating this with states that did and did not increase the speed limit showed that fatalities tended to decrease overall in the states that adopted higher speed limits (Lave and Elias 1997). The explanation was the "ripple effects" whereby people diverted from less safe roads in response to the opportunity to save time; the net result was decrease in the number of fatalities rather than an increase.

Another illustration of substitution affecting safety policies was the proposal that infants travelling on airplanes be required to have their own seat rather than sitting on a parent's lap. This would require that parents purchase an additional seat. As a result, a number of parents travelling on relatively short-haul air routes would divert to automobile travel, a mode less safe than commercial air travel. The net result would be an increase in fatalities rather than a decrease (Windle and Dresner 1991). As a result, the proposed policy was abandoned.

The evidence from the foregoing studies indicates that expected benefits may not be retained, once substitution and system effects are taken into account.

Air bags

The automotive air bag is a remarkable piece of technology. In the event of an impact, sensors detect the sudden deceleration of the vehicle and trigger the inflation of an air bag mounted, for the driver, on the steering wheel and, for the front-seat passenger, on the dashboard. All this takes place, literally, in less than the blink of an eye. To achieve this performance, the air bag must inflate extremely rapidly (with a velocity of about 300 kph). Recently, there has been adverse publicity because a number of people, mostly children and adults of small stature, have been killed by the air bags. The number of deaths reported in North America (61) is small compared to the estimated 1700 lives saved (IIHS 1997). A less well known but similarly adverse fact is that minor and even moderate injuries are worse in air-bag equipped cars than in those not so equipped (Dalmotis 1996). This has given rise to complaints that air-bag performance should be modified and requests by some users that the air bag be disconnected. Air bags are not required equipment in Canada but they are in the United States and, because au-

tomobile manufacturing is integrated across the border, new cars sold in Canada are equipped with air bags.

An important issue is the interpretation of the role of air bags: are they viewed as a system supplementary to seat belts or are they to be a primary safety device, a "passive-restraint" system. If seat belts are worn, air bags offer modest additional protection primarily for frontal collisions. If seat belts are not worn, then air bags are significant protection for frontal collisions.

In the United States, although most states have legislation making the wearing of seat belts mandatory, the estimated percent of drivers wearing seat belts is about 68 percent (NHTSA 1996) compared to about 90 percent in Canada. Because a large number of drivers do not wear seat belts, air bags are mandated to protect these drivers. Injuries and even death can occur in low-speed crashes if the occupants are not buckled. Therefore air bags are triggered by impacts at relatively low speeds (typically 12 kph to 20 kph). But, if occupants of the vehicle are wearing seat belts, there is little or no need for air bags in low-speed impact accidents. It has been discovered that the air bag itself is a major source of injury and has even caused a few deaths.

As a result of the publicity about air bags, some steps are underway to modify them. Air bags are being "depowered" to reduce the likelihood of injury when they inflate. However, this means that when the air bag is really needed, in a high speed crash, the air bag may not be fully deployed when the occupant makes contact with the bag. The air bag will be less effective and even dangerous if the occupant hits the air bag as it first deploys. The threshold deployment speed has not been changed—air bags are still set to deploy in relatively low-speed collisions.

The air-bag controversy raises a number of issues. First, is the debate over using technology to make vehicles safer because people refuse to use seat belts. There is extensive information about the efficacy of seat belts but many people still do not wear them. It appears to be paternalism that is motivating the promotion of air bag technology. Users must pay for them in the price of a car even if they are "standard equipment" (i.e., no extra charge). Those who do use seat belts are paying a substantial price for modest additional protection. If air bags were optional equipment, they could weigh pro and con and decide for themselves if the air bags were worth it to them. As it is, this decision has been made for them. Canada does not require air bags largely due to studies that conclude that the benefits are only marginal given that the vast majority of Canadians wear seat belts (Lawson 1993).

The publicity about air bags may distort rather than clarify the problems and benefits of air bags. If people fear air bags and would turn them off if they could, then this would nullify whatever benefits the air bags have. Prior to the recent publicity, the concern was that people

might overstate the benefits of air bags: if people thought that air bags would protect them, they might not wear a seat belt. If this offsetting behaviour came to pass, air bags would result in a even more injuries and deaths than if they had not been introduced. This is because seat belts protect occupants in a variety of crash situations, whereas air bags are only really effective for frontal impacts. Fortunately, it does not appear that this offsetting behaviour is widespread.

Another less well known cost of air bags is the cost of repairing vehicles and re-installing the bags once they have deployed. The air-bag sensors must be replaced along with the bags, and typically there is extensive interior damage from the air bags themselves. Repairs can run to several thousand dollars. This means cars more than a few years old are likely to be scrapped rather than repaired and air bags are causing many cars to be scrapped that otherwise would have had several years life left in them. It appears that this cost was not given adequate attention in the original decisions to adopt air bags.

There are technological developments that can improve air bags. Research and development is underway to produce "smart" air bags that could modify the deployment depending on the circumstances. One possibility is to have two rates of inflation, one for slow speed impacts and a more rapid deployment for high-speed impacts. Already some manufacturers have passenger-side bags that deploy only if the seat is occupied and sensors could be used to prevent the bag from deploying if the occupant were out of position and too close to the air bag (these have been the cause of deaths). This raises an interesting issue for rapidly evolving technologies. Arguably, there are some shortcomings in the current modifications that are being made to air bags but it is quite possible that technological solutions will solve the problems more quickly than optimal policies could be designed and implemented based on current air-bag design and performance characteristics.

In sum, the adoption of air bags is an example of a policy to adopt a technological solution because people were not making use of available safety equipment. These people would be protected from themselves by mandating air bags in all vehicles. Mandating air bags means every user must pay for the air bags, whether or not they are wanted or needed. Car owners pay for them in the initial purchase price and in the increase in insurance premiums caused by the need to repair the damage caused by air bags that have deployed. The net merits of air bags are debatable at least; they can be valuable *if* vehicle drivers and occupants do not make use of belts though seat-belts are the first choice. If seat-belts are used, as in Canada, the air bags produce a modest additional benefit. The benefits do not necessarily exceed the costs (Waters, 1997; Lawson, 1993). It may be that many people would elect to buy them but, at present, they do not have this choice.

Lessons

The experience with economic analysis of transport regulations is both encouraging and frustrating. It is encouraging because there is considerable experience with, and examples of, CBA and CEA in evaluating transport regulations. It is frustrating because there are persistent policies where economic analysis has little influence (the fuel economy measures might be an example). Economic analysis has been useful but contradictions such as low fuel prices along with fuel economy regulations are not a formula for cost-effective policies. Nonetheless, a review of some of these studies and criticisms of past policies can identify a number of lessons or guidelines to improve the analysis of public policies.

First, while there is a presumption that we seek the most cost-effective policies, it is important to recognize that there can be widely held misconceptions of problems and their solutions. Because politics mirrors popular sentiment, there are times when there will be a conflict between the facts or science of an issue and what is politically feasible and preferred. Academics have the luxury of ignoring and criticizing such situations but civil servants must make the policy process function and must produce acceptable and good policy in the face of special interests, misperceptions, and perhaps even some "junk science" put forward by advocates of certain policies and positions.

Evaluation of costs, effectiveness, and benefits must focus both on direct and indirect costs and consequences. Many criticisms of past policies arose because indirect costs and behavioural responses, which undermined effectiveness, were overlooked. It is important, however, to consider carefully the direct or first-round implications of some action. In evaluating a proposed policy intervention, it is vital to look closely at the claims of costs and effectiveness. Will the policy have the consequences that are desired? What evidence is being put forward? Is it scientific evidence or opinion that is being presented in support of a policy? Further, how much evidence is there? Are there numerous studies or only one or two? Have they been subject to review and criticism so their scientific validity can be assessed?

Along with questions about effectiveness, it must be asked what the costs of the proposed policy are. Costs manifest themselves in various ways. There are costs borne by the implementing agency, which may be separate from costs borne by enforcement agencies or costs borne by the federal government or provinces. And, costs are imposed on users. These may be money costs or costs in time or inconvenience. It is important to recognize the latter, for two reasons: first, these are real costs—opportunities forgone—whether expressed in money or in minutes; second, even if a government agency wished to ignore costs imposed on users in their evaluation, these costs will affect the behaviour of users and this may be important for evaluating the impact that

particular safety policies will have. If a regulation imposes time or similar personal costs on users that can be avoided, then people will try to avoid them and this may undermine the effectiveness of the proposed policy. As noted, there are many examples of people's behaviour modifying the outcome of safety regulations. These are the "downstream" or indirect consequences of some initial policy.

Also, note that, even if it can be demonstrated that a particular policy is cost-effective, this does not mean it is worth doing. CEA is incomplete; a CBA framework tries to measure the value of the benefits derived from a policy and not just whether or not the policy meets some technical criteria. Expressed another way, it is important to assess the worthwhileness of the goals or effectiveness measures that are being pursued.

The more subtle but possibly important effects are the various indirect or "downstream" consequences that follow from a policy, including behavioural responses. Research analysts and policy-makers alike have learned the importance of indirect effects, which often may have been unanticipated and unintended. Often, these indirect effects take time to become apparent. Looking back at the experience in transport regulations, it is the accumulation of indirect and unanticipated consequences that often are the basis for criticisms of policies.

Anticipating behavioural response is an important issue: the nature of regulations is that we are trying to induce people to do something they are not doing at present. It is understandable, even likely, that people will resist interference with their behaviour. The illustration from fuel efficiency is instructive: regulations can modify fuel economy but low fuel prices work counter to this and even encourage automobile-intensive life-styles and choice of car-size can thwart fuel economy. The offsetting-behaviour hypothesis from discussions of transport safety can arise in any field. Policies, however good their intention, will set changes in motion as people respond to the new environment and its signals. In some cases, the behavioural response might thwart the policy intention completely. More typically, it will reduce but not eliminate the desired policy outcomes. In almost every case, this means that policies cannot be as effective as was desired, unless the behavioural responses are anticipated in the design and coordination of policy packages.

In the end, combining good science and good policy is a worthwhile administrative and social goal. There are conflicts along the way, and not all battles can be won but it is a professional responsibility of both researchers and those in the policy-making process to seek a closer link between their respective activities.

Appendix 1
Sample of transportation topics involving economic assessment of risks, costs and benefits

(Gleaned from a review of abstracts generated from a computerized bibliographic search.)

- marine organisms released through ballast water
- ground-water contamination from non-point sources
- truck size and weight limits
- noise and vibration from transport operations and impacts on drivers and nearby residents
- bird strikes at airports
- transport of radioactive materials
- tinted glass on automobiles
- fire danger in underground transit systems
- improving emissions from small engines for use in third-world countries
- air-traffic control standards
- safety of life at sea
- safety implications of environmentally-based regulations on automobiles
- air emissions with alternative fuels
- bridge strength and failure probabilities
- policies to promote car-pooling
- speed-limit enforcement
- "cash for clunkers" to reduce air emissions
- motor-vehicle safety inspections
- air-bag regulations
- bicycle-helmet standards and requirements

- carbon monoxide and other emissions at drive-up facilities (banks, drive-in restaurants, petc.)
- tort liability considerations in developing intelligent vehicle and highway systems (IVHS)
- mandatory use of child seats during air travel
- the implications of economic deregulation for safety enforcement
- profiles of high-risk drivers
- collision risk of oil-tanker traffic
- transportation of people on freight vehicles
- safety of flawed seamless gas cylinders
- traffic signaling, traffic flow, and safety
- motorcycle helmet regulations
- use of cellular telephones and traffic safety
- substance abuse and vehicle operators
- signaling for railroad-grade crossings
- truck-crash rates for diabetic drivers
- mandatory car-trip reduction for large employers
- graduated licensing for automobile drivers
- wind-shear detection for airplanes

Notes

1 For a further discussion of professional backgrounds and how they influence policy analyses, see Weimer and Vining 1992: chap. 1.

2 The origins of cost-benefit analysis (CBA) of public projects began with water-resource projects in the United States, whereas the first applications were in transport in the United Kingdom. The textbooks and articles on CBA in transport often originate outside North America, perhaps reflecting the early application of these techniques. Some countries—notably England, New Zealand, and to some extent, Australia—have extensive experience and reliance on CBA. Many state and provincial highway departments have standardized CBA frameworks and manuals. An institution where CBA is relied upon extensively is the World Bank.

3 The link between vehicle mass and safety is more complicated than this. For example, Greene 1996 (cited at Lave and Lave 1999: 269) notes that CAFE standards tended to reduce the variance in the weights of vehicles on the road. This would tend to make the cars more equal in crashes and thus could entail a safety benefit.

4 Well, not quite a level playing field: focusing on corporate average fuel economy standards gave an advantage to large automobile manufacturers producing a wide range of vehicles, i.e., North American producers. Producers of a narrow range of vehicles were at a disadvantage. A company that produced only large cars (e.g., Mercedes-Benz) could not average this vehicle's fuel economy with those of smaller models. Conversely, manufacturers specializing in small cars (the Japanese manufacturers at the time) did not have the high-end high-markup vehicles to help offset the costs and low margins of the more competitive small-car markets.

References

Aschauer, D.A. (1989a). Is Public Expenditure Productive? *Journal of Monetary Economics* 23: 177–200.

——— (1989b). Public Investment and Productivity Growth in the Group of Seven. *Economic Perspectives* 13, 5: 17–25.

Boardman, A., A. Vining, and W.G. Waters (1993). Costs and Benefits through Bureaucratic Lenses: Example of a Highway Project. *Journal of Policy Analysis and Management* 12, 3: 532–55.

Crandall, R.W. (1984). Automobile Safety Regulation and Offsetting Behaviour: Some New Empirical Estimates. *American Economic Review* (May: Papers and Proceedings): 328–31.

Crandall, R.W., and J.D. Graham (1989). The Effect of Fuel Economy Standards on Automobile Safety. *Journal of Law and Economics* 32 (April): 97–118.

Crandall, R.W., and L. Lave, eds. (1981). *The Scientific Basis of Health and Safety Regulation*. Washington, DC: Brookings Institution.

Gillen, D.W. (1996). Transportation Infrastructure and Economic Development: A Review of Recent Literature. *Logistics and Transportation Review* 32, 1: 39–62.

Dalmotas, D.J. (1996). Performance of the Combination Manual Three-Point Seat Belt and Supplementary Restraint System Based on US Field Accident Data. Discussion Paper (January). Transport Canda, Road Safety and Motor Vehicle Regulation Directorate, Ottawa.

Greene, D.L. (1996). *Transportation and Energy*. Lansdowne, VA: ENO Transportation Foundation.

Howitt, A.M., and A. Altshuler (1999). The Politics of Controlling Auto Air Pollution. In J.A. Gomez-Ibanez, W.B. Tye and C. Winston (eds.), *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer* (Washington, DC: Brookings Institution): 223–55.

Insurance Institute for Highway Safety [IIHS] (1997). *Airbag Statistics*. Digital document: www.hwysafety.org/PASSVEH/Abstates.htm.

Lave, C., and L. Lave (1999). Fuel Economy and Auto Safety Regulation: Is the Cure Worse than the Disease? In J.A. Gomez-Ibanez, W.B. Tye, and C. Winston, eds., *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer* (Washington DC: Brookings Institution): 257–89.

Lave, C., and P. Elias (1997). Resource Allocation in Public Policy: The Effects of the 65-mph Speed Limit. *Economic Inquiry* 35 (July): 614–20.

Lave, L., and W.E. Weber (1970). A Benefit Cost Analysis of Auto Safety Features. *Applied Economics* 2: 265–75.

Lawson, John (1993). Cost-Benefit and Cost-Effectiveness Assessments of Potential Regulation Requiring Air Bags in Passenger Cars in Canada. *Chronic Diseases in Canada* 14, 4 (supp.): S93–S100.

Leone, R.A. (1999). Technology-Forcing Public Policies and the Automobile. In J.A. Gomez-Ibanez, W.B. Tye, and C. Winston, eds., *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer* (Washington DC: Brookings Institution): 291–323.

National Highway Traffic Safety Administration [NHTSA] (1996). Effectiveness of Occupant Protection Systems and Their Use. Third Report to Congress (December). Washington, DC: United States Dep't of Transport. Digital document: www.nhtsa.dot.gov./cars/rules/rulings/208con2e.html.

Peltzman, S. (1975). The Effects of Automobile Safety Regulation. *Journal of Political Economy* 83: 677–725.

Small, K. (1999). Project Evaluation. In J.A. Gomez-Ibanez, W.B. Tye, and C. Winston, eds., *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer* (Washington DC: Brookings Institution): 137–77.

Waters, W.G., II (1997). Overblown! Examining the Costs and Benefits of Automotive Air Bags in Canada. In *Proceedings,* Canadian Transportation Research Forum (Saskatoon, SK: University of Saskatchewan Printing Services): 625–43.

Weimer, D.L., and A.R. Vining (1992). *Policy Analyses: Concepts and Practice* (2nd ed). Englewood Cliffs, NJ: Simon and Schuster.

Windle, R.J., and M.E. Dresner (1991). Mandatory Child Safety Seats in Air Transport: Do They Save Lives? *Journal of the Transportation Research Forum* 31, 2: 309–16.