Who's in the Driver's Seat? Mobile Source Policy in the U.S. Federal System

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Abstract

Regulation of mobile source emissions in the US has evolved as a complex combination of central government and decentralized authority. The central government required uniform new car emissions standards in the 1970 Clean Air Act, but gave states the power to meet ambient air quality standards however they saw fit, including various regulations on mobile sources. The 1990 Amendments to the Act strengthened the Federal role in some ways, by requiring tighter new car standards and more specific requirements for fuels and for vehicle emissions inspection and maintenance, but at the same time left states with a great deal of latitude to meet ambient standards and took greater recognition of regional variation in environmental problems. We examine the role of various levels of government in attempts to control vehicle emissions in the U.S., focusing primarily on regulations affecting ambient ozone pollution.

Current regulations coming out of the 1990 Amendments are still the subject of much controversy. Several regulations are examined here from the federalist perspective, including the California new car standards and the current debate over "enhanced" inspection and maintenance. We discuss the theoretical basis for national uniform regulations, including production scale economies for new cars, pollution spillovers from one jurisdiction to another, and prevention of state non-compliance with ambient air quality goals. For the analysis of economies of scale in production, we model the trade-offs between gains from scale economies in polluted regions and losses from excess controls in cleaner regions, and illustrate the role of interregional transfers or side-payments. These trade-offs and transfers are particularly important as decisions are being made about whether the "California cars" will be sold only in California or whether they will be sold in the Northeast states and elsewhere. We then look at the debate over enhanced I&M. Finally, we draw some tentative conclusions about the future role of the states versus the central government in US ozone policy.

Key Words: mobile source, federalism

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INTRODUCTION

In the United States, scholars, policy makers, and the American people have debated the appropriate assignment of responsibilities among the multiple layers of government since the time of the Founding Fathers. In theory, the federal system of government should create the opportunity to reach more efficient outcomes than would a unitary system. Local and state governments can make policy decisions that are in the interests of their own citizens without imposing harm on the rest of the country. And when clear national objectives exist, the central government has the power to impose laws or regulations that apply to all citizens. In practice, however, this ideal outcome may not always be achieved.

This paper describes the assignment of responsibilities for control of motor vehicle emissions and ambient ozone policy among the states and the central government. First, an historical overview of policymaking in the U.S. from the 1970 Clean Air Act to the 1990 Clean Air Act Amendments (CAAA) is presented. The 1970 law introduced a strong federal role in air pollution policy by establishing national air quality goals, but, for the most part, granted states a great deal of latitude in meeting those goals. The 1990 CAAA, in response to the lack

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of progress toward air quality goals, particularly the ambient ozone goal, took a more prescriptive centralized approach in several important ways. Arguments for and against a centralized approach to ozone policy are presented and some key provisions of the 1990 law are evaluated.

Particular attention is paid to new car emissions standards and motor vehicle inspection and maintenance (I&M) programs. With the exception of California, which is allowed to have its own (stricter) set of standards, new car standards have always been established at the national level. One of the main arguments for such a centralized approach has been that economies of scale in car production would lead to very high costs in the event of multiple standards. This paper evaluates this economies of scale argument in the context of current and proposed regulations in the US. The welfare implications of a provision in the CAAA that allows states for the first time to adopt California's stringent standards are assessed. I&M programs were only suggested by the 1970 law but very rigid I&M requirements were laid out in the 1990 CAAA and subsequently by the US Environmental Protection Agency (EPA). The reasons for this and the efficacy of such an approach are examined. Finally, some conclusions are offered and lessons drawn from the US experience.

BACKGROUND ON FEDERALISM AND CLEAN AIR POLICY IN THE UNITED STATES

Those who study the history of the US government find that federalism has taken various forms over the course of the country's existence. Mason [1972] views the period up to 1861 as a period of "dual federalism," a time when states and the central government each had their own particular responsibilities and acted independently of each other. From 1861 to the New Deal, a gradual centralization occurred. The New Deal then ushered in a new era with central government programs and regulations growing sharply. At this point, "intergovernmental relations," or cooperation between the central government and the states, emerged as the new federalism.

As concern about air pollution grew throughout the 1950s and 1960s, it was perhaps no surprise that the federal government took such a strong role in establishing the 1970 Clean Air Act. The Act gave the central government the broad power to set national uniform air quality standards which the states would enforce. States were required to formulate "State Implementation Plans (SIPs)" that laid out policies they would use to attain those standards. In theory, at least, this approach leaves the door open for states to try many different approaches to reach the standards.[2] There was one exception to this, however: only California was allowed to set its own new car emissions standards; other states had to abide by one set of standards that were written into the law itself.

The approach taken by the CAA of 1970 seemed to work for particulates, sulfur dioxide, and carbon monoxide but not for ozone. Ozone is not emitted directly from motor vehicles and stationary sources but rather is created in the atmosphere by the reaction of volatile organic compounds (VOCs) and nitrogen oxides (NOx) in the presence of heat and sunlight. Ozone concentrations remained stubbornly high over the 1970s and 1980s despite apparent reductions in VOC and NOx emissions.[3] With a large portion of VOCs and NOx in

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[2] Portney [1990] has argued that EPA enforcement of environmental regulations has not given much real flexibility to the states, since if they do not require the EPA "suggested" technology, they will not get full credit for the emissions reductions. More is said about this with respect to mobile source policy below.

[3] There is some debate about whether VOCs fell by as much as the Environmental Protection Agency's emissions models suggests. Many scientists feel, for example, that inventory model estimates of evaporative VOCs were grossly underestimated [Calvert et al. 1993].

nonattainment areas coming from motor vehicles, Congress focused on those sources in revisions to the 1990 CAAA. New car tailpipe emissions standards were tightened and a host of requirements were imposed on ozone nonattainment areas. These requirements included implementing so-called "enhanced" inspection and maintenance (I&M) programs, selling reformulated gasoline, instituting "employee trip reduction" (ETR) programs, and requiring the use of alternative fuels such as methanol and natural gas in fleet vehicles. The requirements varied across areas by the degree of nonattainment, but the CAAA allowed areas not subject to some of the requirements, to "opt-in" to those requirements.[4] For the first time, it also allowed the most polluted states to adopt California new car emissions standards. These standards are very stringent and are scheduled to become more so in the future with some portion of vehicle sales in each year required to be electric vehicles.[5] In a controversial move, the Ozone Transport Commission (OTC), which governs air quality in the Northeastern states, voted in 1994 to request that EPA approve the adoption of the California standards in 12 Northeastern states and the District of Columbia. EPA approved in December 1994 but also

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[4] For example, many areas have chosen to adopt the reformulated gasoline requirement.

[5] States that have "serious," "severe" or "extreme" ozone nonattainment areas can petition the EPA to adopt these standards. The standards, described in more detail below, are fleetwide average new car standards that get progressively more stringent over time beginning with the 1996 model year. Manufacturers can meet the fleetwide average with a combination of vehicles meeting so-called "low-emission vehicle (LEV)," "ultra-low-emission vehicle (ULEV)," and "zero-emission vehicle (ZEV)" standards. Beginning in 1998, however, 2 per cent of sales must be comprised of ZEVs, i.e., electric vehicles, and the percentage rises over time to 10 per cent by 2003. It should be noted, however, that electric vehicles are not really zero emission vehicles. Their use would create the need for more electricity generation which has its own associated emissions and the disposal of lead batteries can result in substantial environmental damage.

left the door open for an industry-proposed alternative, the so-called "49-state car." Negotiations between the industry and the Northeastern states are continuing.[6]

The 1970 Act and its subsequent amendments were supposed to build a new partnership between the states and central government in which the central government set standards and the states met and enforced those standards. However, the language of the Act itself in establishing the targets for ambient air quality standards may have set up a conflict between state and central levels of government. The Act requires that ambient air quality standards be set to protect the most sensitive individuals in the population with a margin of safety. This meant that national air quality standards had to be set which would ignore the regional costs of attaining those standards. The national standard is, therefore, not likely to be the standard each of the states would have chosen for itself. Subsequent national regulations including the Clean Water Act of 1972 and the Coastal Zone Management Act did attempt to account for the costs of control or of "consistency" between national actions and state wishes in establishing regulations. But the Clean Air Act has left itself open to serious enforcement issues as states face national requirements that clearly result in costs exceeding benefits.

The 1994 elections, in which Republicans gained control of both the US Senate and the House of Representatives, may lead to dramatic changes in clean air policy. The rallying cry of the states, which now appears to be falling on sympathetic ears in Congress, is "no unfunded mandates" from the central government. This movement, along with disastrous starts for

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[6] The "49-state car" will meet a California LEV emission standard (less than .07 grams per mile HC); however, since cars in the rest of the country will use a different gasoline than California, in-use HC emissions are predicted to be about 30 per cent higher. The industry has agreed to sell the cars nationwide beginning in 2001, with some being sold earlier in the Northeastern states.

enhanced I&M programs in many states, seems likely to lead to significant environmental policy changes. Whether or not a move toward assignment of more responsibilities to the states and fewer to the central government is a good idea and if so, what those responsibilities should be, is discussed in the following section.

ECONOMIC EFFICIENCY ARGUMENTS

A. Decentralized Control

There are many compelling reasons for assigning ozone policy to state and local governments. First, the costs and benefits of clean air can vary geographically for a number of reasons. The costs of reducing ozone in the Los Angeles area (LA), for example, are very high because the meteorology and topography there create unique conditions conducive to ozone formation. A reduction in emissions in LA does not go as far toward reducing ozone concentrations as does that same reduction elsewhere. This forces LA toward greater reductions at higher marginal cost. The benefits of clean air can vary as well. One obvious way they vary is with population since a given reduction in ozone in a heavily populated area will generate greater benefits than that same reduction in a less populated area. Moreover, if clean air is a normal good, then the benefits of ozone reduction may be higher in areas with higher levels of income. Since local jurisdictions are best able to judge the costs and benefits of policies to reduce ozone pollution in their own regions, assuming no spillovers [Oates and Schwab 1988], policies should be set at the local level.

Secondly, society can benefit from having a diversity of public goods available -- including varying levels of clean air. Because individuals have different preferences for both public and private goods, when a mix of public goods is available across communities, individuals will choose to live in communities that offer the combination of public goods best suited to their tastes and income [Tiebout 1956]. The more diversity there is across communities, the better chance individuals have of finding a community that is right for them.

In principle, it is possible for the national government to account for differences in costs and benefits across regions and establish geographically different policies and regulations. In practice, however, this tends not to occur. Because it is difficult to gather and process information about benefits and costs in many different areas and because the central government is more removed from the problem, regulations from the central government tend toward uniformity. Moreover, in the 1970 Clean Air Act, Congress had a clear national objective in mind: to protect the health of the most sensitive individuals in the population. This led to uniform ambient air quality standards, ruling out consideration of variations in benefits across regions.

Even with a national objective applied to all areas, though, there is still the issue of assigning responsibility for determining appropriate control strategies and for implementing those strategies. Again, the central government can, in principle, account for differences in costs across regions and determine cost-effective strategies. The 1990 CAAA attempted to account for some regional differences in costs by designating regions within broad ozone categories, and then requiring additional and often stricter policies in the more polluted regions. For example, "enhanced I&M" is only required in areas that are designated as "serious" ozone non-attainment areas or worse. However, the costs to the national government of determining the most cost-effective regulations for each region, then monitoring and enforcing those regulations, may be quite high. Even though enhanced I&M is required only in the most polluted regions, what is considered enhanced I&M by the EPA was established uniformly for all those regions, in part because of the difficulty in monitoring many different types of programs.

This leads to a third reason why a decentralized approach may be preferred. Not only are states thought to have better information about their own costs and about what approaches work within their borders, but they are often thought to be more innovative and flexible in finding solutions to problems than the national government. Supreme Court Justice Louis Brandeis stated that: "it is one of the happy incidents of the federal system that a single courageous State may, if its citizens choose, serve as a laboratory; and try novel social and economic experiments without risk to the rest of the country."[7] California, and Los Angeles in particular, has served as a laboratory for ozone policy for a number of years. Because of its large size and severe air quality problems, it has been in the interest of Californians to experiment with approaches that the central government (or other smaller states) probably would not have tried. As a result, some of the approaches pioneered by California in the 1980s (for example, ETR programs and alternative fuels provisions), became part of the broader regulations of the 1990 CAAA. California seems to be moving now toward more economic incentive approaches such as emissions-based vehicle registration fees and vehicle scrappage programs. It will be interesting to note to what extent these less costly and more efficient

[7] *New State Ice Company v. Liebmann,* 285 US 262, 311 [1932].

alternatives [see Harrington, Walls, and McConnell 1995] end up being adopted by other states or by the central government.[8]

B. Centralized Control

In spite of the arguments suggested above, there are a number of reasons why the central government could play a role in environmental policy to reduce ozone pollution. Most of the arguments for a strong central government role in ozone policy revolve around the issues of spillovers and economies of scale. In the case of ozone control, there is the additional issue that the social welfare goal of the central government may be different than the goal or goals chosen by the state governments. Each of these is discussed below.

Spillovers

First, if VOC and NOx emissions in one state contribute to ozone in another state, the first state acting alone would fail to account for the spillovers and would not do enough to curb its emissions. In the US, ozone spillovers occur to a significant degree in the Northeast corridor and in the Chicago-Milwaukee-Great Lakes region. The importance of spillovers in the Northeast led Congress to identify this as a separate region. The CAAA initiated the Ozone Transport Commission (OTC), which now coordinates policy decisions in 12 Northeastern states and the District of Columbia.

Secondly, positive spillovers can be generated from policies themselves and states acting alone will fail to take this into account. It was mentioned above that California has

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[8] Rose-Ackerman [1981] shows that a single state that imposes a tighter-than-average regulation has an incentive to lobby other states to pass similar regulations. By effecting such regulations, it lowers its own costs.

undertaken numerous actions on its own which have eventually been adopted by the central government and by other states. It is widely agreed, for example, that California's stringent new car emissions standards (the ZEV standard, in particular) are responsible for a rash of new research on electric motors and other alternative propulsion systems and fuels. Although California is evidently large enough to reap positive benefits from acting alone, it is probably doing less than it would if it accounted for policy spillovers. Moreover, smaller states considering these same actions would almost certainly face costs far in excess of benefits unless other states adopt similar policies. This suggests that there may be serious free rider problems necessitating a role for the central government.

Economies of scale

A related concern about decentralized policymaking centers on administrative economies of scale. The cost to 50 state governments of gathering information about the costs and effectiveness of different control strategies, then deciding on the exact form that these strategies should take, and finally, implementing, monitoring, and enforcing these control strategies could be high, much higher than if some of that effort was expended by the central government and shared with all states. This contrasts with the observation above that state and local governments may be better able to estimate costs and effectiveness of different control strategies since they are closer to the problem than the central government. Both effects could be at work; which one dominates depends on the control strategies being considered.

Production economies of scale have been used as one of the major arguments for central government control, particularly in the area of new car emissions standards. When

California and New York established separate sets of standards for emissions in the 1960s, the auto companies argued that it would be very costly to produce vehicles to meet many different standards. They convinced Congress of this point of view and ended up with one set of national uniform emissions standards with the exception of California, which was allowed to have its own more stringent standards [Elliott, Ackerman, and Millian 1985]. In the 1990 CAAA, other states were permitted to adopt the California standards for the first time.

The existence of production economies of scale does not alone justify uniform standards set by the central government. Scale economies imply only that costs will be lower with a uniform standard compared to the case of regionally differentiated standards. Centralized regulation is needed only if it reduces the transactions cost of reaching a uniform standard or if it permits a different and more socially beneficial uniform standard to be reached than would occur if the states or firms were acting independently.

The problem can be illustrated by assuming there are two regions, A and B, and one or more manufacturers supplying automobiles to consumers in both markets. If region A sets a strict new car standard, the manufacturers must decide whether to produce separate cars for regions A and B or to produce the cleaner car in both regions. That decision will depend on industry structure, but if there are competitive conditions, price will be equal to average cost, and the firm will have zero profit in either case and will be indifferent to producing a single car or different cars in the two regions.[9] It is assumed here that rivals will keep prices close to the

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[9] In this simple model it is assumed that rivals can enter the market instantaneously by simply paying the cost of entry. This abstracts from the more realistic situation in which, for example, the cost of entry may be different (and greater) for new entrants or where delays in response to a change in market conditions can give the existing firm an opportunity to earn rents temporarily.

competitive level, but monopoly pricing is also possible and leads to different conclusions. (The monopoly case is shown in Appendix 1.)

Even though firms are indifferent about producing one car or two, the interests of the consumers in the two regions may be divergent. When region A unilaterally decides to raise its emission reduction requirements, and the firm decides to offer a single car for sale in both regions, consumers in region A will be clearly better off as economies of scale make their vehicles less expensive than they otherwise would be. However, if the firm raises the price in region B to recover its average production cost everywhere, it becomes vulnerable to an entrant that will produce cheap, dirty cars for sale there. Fear of entry may thus keep the firm producing two cars for the separate markets, an action which ensures that consumers in B pay the lowest possible prices for vehicles, and no uniform standard by the central government is required.

Nonetheless, the two-car, separate market outcome may be suboptimal once air quality benefits are examined. This possibility is illustrated in Figure 1, which shows the demand for vehicles, the costs of vehicle production, and environmental damage from vehicles in region B, the region that did not initiate the clean car. The three cost curves represent the cost per vehicle of the original dirtier car, AC_D, the cost of the cleaner car when both regions A and B adopt it, AC_C^{A+B}, and the cost when only region B adopts it, AC_C^B. If clean cars are produced in both regions, region B faces costs of AC_C^{A+B} and area K represents the loss in consumer surplus because the region pays higher prices for a cleaner car compared to the original dirty

Figure 1 is available from the authors
at Resources for the Future.

car. If the loss in consumer surplus is less than the reduced damages from driving cleaner cars (Area M), the citizens in region B would be better off with the clean vehicle.

However, there are a number of reasons why Region B may not adopt the stricter standard even though social welfare would be greater if it did. First, the costs to B will depend on whether Region A or other regions are adopting the standards and that information may difficult to obtain. From Figure 1, regional environmental authorities in region B may not know whether they are facing costs for the clean car of AC_C^{A+B} or AC_C^B. Hence, regions may not adopt, because they do not know who else will adopt, or if they do adopt first, they may try to convince other regions to adopt in order to lower their own costs.[10] Both regions might be better off if the central government stepped in and either made cost information available or set a uniform standard.

A second possibility is the case in which Region A adopts the stricter standard first, and Region B, based on its own costs and benefits, elects not to adopt. However, Region A benefits from lower costs when B adopts. If Region A can compensate Region B, it becomes efficient for B to adopt. Again, there may be a role for the central government in facilitating side-payments or differential taxes, or even in setting a uniform standard.

The case of monopoly in the car market yields slightly different results (see Appendix 1). It appears that regardless of the industry structure, it is difficult and perhaps impossible to come up with simple rules for determining when central government intervention is justified on the basis of production economies of scale. One conclusion is clear: the simple existence of production economies is not sufficient to warrant central government involvement. Below, the welfare impacts of adoption of the California new car standards in the rest of the US are considered.

C. What Role for the Central Government?

Even if it is determined that spillovers and/or economies of scale are significant, it remains to be seen what the central government's role should be. Would it design and implement policies, simply provide information to the states, or give states financial or other incentives to incorporate spillovers? What should be its role with respect to monitoring and enforcement activities?

The existence of spillovers or economies of scale does not mean that a strong decentralized approach must be abandoned in favor of uniform national requirements. For emissions spillovers, it may mean that the central government simply needs to facilitate cooperation and bargaining solutions – like supporting the OTC's activities in the Northeast. It may mean that it go a step further and set non-uniform emissions targets that account for spillovers, but it could then leave the design and implementation of control strategies up to states.[11]

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[10] California has been pressuring both Massachusetts and New York to maintain their position on requiring a percentage of electric vehicles in the fleet early in the next decade. California is required to have some electric vehicles, and would benefit from other states adopting similar requirements due to economies of scale.

[11] Smith [1994] argues against this solution for the countries in the European Union since monitoring and enforcing compliance becomes very difficult compared to monitoring and enforcing compliance with a EU-determined tax. His argument may hold for carbon emissions where one can tax the pollutant directly but since ozone is not directly emitted and its formation is complicated and dependent on local conditions, it may be more efficient to allow for more decentralized control over choice of ozone policies.

Another possibility is the use of selective "matching grants" from the central government to the states [see Oates 1972]. If the central government knows the magnitude of the externality imposed on New York from emissions in Maryland, it can compensate New Yorkers to put up with the externality or, equivalently, it can subsidize Marylanders for increased emissions reductions.

Several provisions of the 1990 CAAA offer opportunity for changes in the role of the central and state governments. We will examine several of these as examples of current federal issues in the US. First, the Act allows for states other than California to adopt the strict California new car standards. Using estimates of economies of scale in production of the new technology vehicles, the welfare implications when different states or regions adopt the standards can be determined. The appropriate role of the federal government will be examined. We then turn to a brief analysis of the controversy in the US between the Federal government and the states over autonomy for vehicle inspection and maintenance programs.

FEDERALISM, ECONOMIES OF SCALE AND NEW CAR EMISSIONS STANDARDS IN THE US

New car emissions standards in the US provide an interesting application of the impact of scale economies on the appropriate level of government regulation. The 1990 Amendments to the Clean Air Act required several new rounds of national new car standards and California established its own stricter standards. Table 1 summarizes these standards for hydrocarbons (HC) and for nitrogen oxides (NO_X). The Federal Tier 1 standards are to be phased in during the mid 1990s and the Tier 2 standards will be required in 2003 if the EPA determines that they are necessary to meet air quality goals.

Table 1: National and California new car standards

	Hydrocarbons (g/mile)	Nitrogen Oxides (g/mile)
Federal		
1993 vehicle	0.4	1.0
Tier 1	0.25	0.4
Tier 2 (if necessary)	0.125	0.2
California		
1993 vehicle	0.25	0.4
TLEV	0.125	0.4
LEV	0.075	0.2
ULEV	0.04	0.2
ZEV	0.0	0.0

California's "Low Emission Vehicle" (LEV) program, established in 1990, sets a HC standard that becomes stricter in successive years, starting with the 1994 model year [CARB 1990]. To be in compliance, each manufacturer must sell vehicles so that average emissions across the fleet (weighted by sales) achieve the specified standards. Manufacturers can produce and certify vehicles with different emission levels: "Transitional Low Emission Vehicles (TLEVs), Low Emission Vehicles" (LEVs), "Ultra Low Emission Vehicles" (ULEVs) and "Zero Emission Vehicles" (ZEVs), whose emission standards are shown in Table 1. These vehicles, in combination with new cars meeting the federal standards can be produced in any combination to meet the average California HC standards. Table 2 shows estimates of how manufacturers may choose to achieve these standards through the year 2003. The last column of this table shows the actual California standards.

Table 2: California standards and possible vehicle distribution to meet them
(Hydrocarbon emissions)

	Vehicle certification (grams/mile)						
			TLEV	LEV	ULEV	ZEV	
Model Year	.39	.25	.125	.075	.04	.00	Average Standard
1994	10%	80%	10%				.250
1995		85%	15%				.231
1996		80%	20%				.225
1997		73%		25%	2%		.202
1998		48%		48%	2%	2%	.157
1999		23%		73%	2%	2%	.113
2000				96%	2%	2%	.073
2001				90%	5%	5%	.070
2002				85%	10%	5%	.068
2003				75%	15%	10%	.062

From: Sierra Research, Inc. "The Cost-Effectiveness of Further Regulating Mobile Source Emissions," Report No. SR94-02-04, February 28, 1994.

The 1990 CAAA took a different approach from the earlier legislation and allowed other states or regions to adopt the California standards. The Ozone Transport Commission in the northeastern US has been given approval by EPA to adopt the California standards. In this section, the resulting changes in consumer and producer surplus in California and in the Northeast OTR from the Northeastern states' adoption of the California package are estimated.

As shown above in Figure 1, the costs of imposing stricter new car standards in any region will be the resulting change in consumer surplus, which depends on the difference in average costs between new cars with the stricter standards and with existing standards, and the elasticity of demand for new cars. The former depends on the number of other regions adopting the standard. For this analysis, it is assumed that the cost of a new car varies with volume (scale economies) and by type of car. It is also assumed that cars are produced under competitive conditions.[12]

The per vehicle costs of meeting either the national or California standards are uncertain, and there are a wide range of estimated costs.[13] For this analysis, cost estimates from Sierra Research, Inc. [SRI 1994] are used, which are based on data from surveys of car manufacturers. The SRI cost estimates include the equipment, redesign and operating costs required to meet the standards, as well as any additional manufacturer R&D, overhead and selling costs. The SRI analysis makes the assumption that there will be substantial learning as new technologies are developed, resulting in declining manufacturing costs for any vehicle type over time.[14] The SRI estimates of the average costs over the life of a vehicle in 1993 dollars are shown in Table 3.[15]

[12] The assumption of competition is probably reasonable for current car markets and, in any case, no information about excess profit margins was available.

[13] In fact, discussions with industry officials reveal that new car prices will not necessarily reflect the emissions control components on the car. Higher standards in one region may end up getting spread across costs of cars sold everywhere. This is not the case examined here, but it would be interesting to look at the efficiency and distributional consequences of that kind of pricing.

[14] The Sierra Research analysis assumed that labor costs would decline by 5 per cent as labor became more experienced with any particular car, and that engineering, tooling and equipment costs would decrease by 50 per cent for each 5 year production cycle. It was also assumed that new vehicle dealers would only be able to realize 50 per cent of their standard price mark-up [Sierra Research Institute 1994, p. 98].

[15] These estimates are between high cost estimates from the auto industry and lower estimates from the California Air Resources Board [Automotive Consulting Group 1993; CARB 1990].

Table 3: Costs and emissions reductions of California new car standards relative to meeting the 1993 national standards					
	Emissions Reductions* (lbs over vehicle life)		Costs/vehicle		
	HC	NOx	California Only	Nationwide	California and Northeast Ozone Transport Region
Tier 1	27.17	64.29	284	142	253
TLEV	41.61	65.20	463	344	408
LEV	49.53	86.08	1,019	775	894
ULEV	55.79	86.08	1,116	979	980
ZEV	200.08	247.65	21,034	12,588	12,824

* relative to baseline Federal vehicle (per vehicle).

From: Sierra Research, Inc., "The Cost-Effectiveness of Further Regulating Mobile Source Emissions," Report No. SR94-02-04, February 28, 1994.

Benefits in any region depend on the emissions reductions from the new car policy, and the value of any resulting air quality improvement. It will be assumed that the marginal emissions reductions over the baseline Federal vehicle are the same for each technology type for each pollutant across regions, as shown in Table 3. However, the dollar value of any emissions reductions will depend on the type of pollutant and the region, since the link between emissions and air quality varies greatly across regions and times of the year. In regions that are NOx limited, reductions in VOCs will have little or no impact on ambient ozone, and the benefit of VOC reductions are close to zero. In addition, recent evidence suggests that vehicle emissions of VOC and NOx may also combine to form aerosol particulates which are more damaging to human health than increased levels of ambient ozone [Hall et al. 1995].

Estimates of the benefits of reduction in car emissions vary over a wide range. The estimates used in this study are drawn from the literature (see Table 4). Small and Kazimi [1994] summarize the existing studies and provide average estimates of benefits for California. Sierra Research [1994] also uses estimates from the literature for benefit estimates for the nation as a whole and for various regions. The estimate used for California, \$10/pound or \$20,000/ton of HC, is a little greater than the average from the Small and Kazimi study and is close to that suggested by Sierra Research. The OTR and rest of the nation benefits estimates are from Sierra Research [1994]. These benefits estimates all are high, because they include substantial particulate mortality benefits for NOx reductions about which there is substantial controversy. Other benefits estimates are much lower [Krupnick and Portney 1991].

Table 4: Benefits assumptions

Region	Benefit of HC reduction	Source
California	\$10/lb	Small and Kazimi (1994) and Sierra Research (1994)
OTR	\$3/lb	Sierra Research (1994)
Nation	\$1/lb	Sierra Research (1994)

To examine the welfare implications of allowing states or groups of states to adopt the California standards, the costs and benefits must be aggregated across all cars in the region.[16] The aggregate costs and benefits of the increasingly tight standards are considered by looking at each year separately.[17] Table 5 shows the calculations of the costs and benefits as depicted

[16] Vehicle populations for 1994 are taken from the Motor Vehicle Manufacturer's Association [1994].

[17] The successively tighter California standards are currently packaged as a whole that regions can either adopt or not adopt. However, it is clear from the welfare estimates presented that packaging them may not be appropriate. Some of the early year standards appear to be much more cost-effective than those of the later years.

in Figure 1[18] for California and for the nation as a whole for adopting the successively stricter fleet average standards shown in the last column of Table 2. For California acting on its own, the costs and benefits are very close in early years when only a small share of the relatively inexpensive TLEVs are needed to meet the standards. In 1997, when LEVS and ULEVs are introduced, the costs rise dramatically. However, if the entire country were to adopt the stricter standards, California's costs would fall as production economies are realized. The savings are large for California, and for the early years through 1996 during which TLEVs are sold, the benefits exceed costs for California if the clean cars are produced everywhere.

However, if the country as a whole adopts the California standards, even in the early years, the costs outside of California far exceed the benefits. Even if California could make some kind of side-payment to the rest of the country, the net costs to the rest of the country would still be quite high. It is important to note here, as discussed above, that the national ambient air quality standards reflect a safety standard, not an efficiency standard. So it is not surprising that the costs may exceed the benefits. It is also not surprising, given these estimates, that many states might not implement these standards unless required to do so.

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[18] The calculation of costs and benefits here is slightly different than the dark areas depicted in Figure 1. First, benefits are constant for each type of vehicle in each region, instead of increasing with the number of vehicle as Figure 1 shows. Second, we have not included the costs or benefits of reduced car sales that would result when there are higher prices for the less polluting cars - the areas resulting from a decline in cars from N_D to N_C.

Table 5: Costs and benefits of adopting California new car tailpipe standards

(relative to 1993 Federal vehicle, millions of 1993 dollars)

	California			Entire US	
	Costs if only California adopts	Costs if entire US adopts	Benefits	Costs	Benefits
1994	233	126	220	1260	221
1995	265	147	250	1467	250
1996	272	155	256	1554	256
1997	583	420	276	4200	276
1998	909	605	316	6084	314
1999	1066	740	364	7408	362
2000	1209	864	408	8649	406

We now turn to another debate over new car standards in the US, which is the issue of whether the states in the Northeast should adopt the California standards. Table 6 shows the results of estimates of the welfare impacts of the California new car standards in California and the Ozone Transport Region (OTR) of the northeast US. The size of the OTR new car market is about 2 to 3 times the size of the California market, so extending the California standards to the OTR provides substantial savings from economies of scale. It is again clear that California has a strong incentive to try to persuade the OTR to adopt the California standards, since there would be substantial savings to them if the OTR does adopt. According to the estimates, however, costs exceed benefits for the OTR, <u>even if California were to make a side-payment to the OTR</u>.

It is striking how costly the standards in the later years are estimated to be when ULEVs and ZEVs must be included in the fleet. The results are even more conclusive, because the benefit estimates used for this analysis are at the high end of current estimates. However, given the way the central government sets ambient air quality standards – to protect the most sensitive individuals – it is not surprising that the costs of policies such as the new car standards are high and often exceed benefits. The most that can be hoped for is that states or regions adopt policies that are cost-effective in reaching the air quality goal.

The cost-effectiveness of the California standards in the Northeast OTR, measured as the cost per ton of HC emissions reduced, is $16,500 in the early years (with TLEVs and a few LEVs) without a side-payment from California, and $14,000 with a side-payment. In the later years, when more LEVs and ULEVs are sold, the costs rise to $40,000 to $60,000 per ton of HC reduced.[19] These estimates are higher than the costs of many alternative measures the OTR could adopt. For example, Krupnick, Walls, and Hood [1993] estimate that a small gasoline tax increase would cost slightly less than $5000 per ton of HC reduced. Alberini, Harrington, and McConnell [1994] estimate a cost-effectiveness for accelerated vehicle scrappage programs of less than $6000 per ton. Emissions-based vehicle registration fees look even more promising, with preliminary cost-effectiveness estimates as low as $1650 per ton [Energy and Environmental Analysis 1993].

Public acceptance of such approaches may be difficult, however, and many of the other relatively low-cost options available for reducing emissions – for example, reformulated gasoline and enhanced I&M are already in place in the Northeastern states. More strict fuel reformulation requirements, such as those in California, or requirements for alternative fuel vehicles could result in very high costs, higher than the $14,000 per ton for the early phases of the California standards. However, currently the OTR cannot adopt only the first phases of the California package, they must adopt the entire California package or none of it. This inflexibility means that the OTR will probably not adopt the California standards since taken as a whole they are not cost-effective.[20]

Table 6: Costs and benefits of adopting California new car tailpipe standards in California and the Ozone Transport Region

(millions of 1993 dollars)

	California			OTR			
	Costs		Benefits	Costs		Benefits	
Year	Only CA Adopts	CA and OTR Adopt		Only OTR Adopts	CA and OTR Adopt	No payment from CA	With side-payment
1994	233	183	220	569	447	162	211
1995	265	209	250	646	510	183	239
1996	272	216	256	665	527	187	244
1997	583	480	276	1425	1174	202	305
1998	909	661	316	2221	1620	231	479
1999	1066	791	364	2603	1932	266	540
2000	1209	911	408	2955	2225	298	596

It can be concluded that the policy of allowing California to set separate stricter new car standards is reasonable, since there appears to be evidence that the benefits of emissions

[19] Since costs exceed benefits in California in the later years, there is no side-payment to be made.

[20] The "49-state car" option is not evaluated here but should be much more cost-effective for the OTR. The question, however, is the cost it imposes on other regions of the country.

reductions in California are high. For TLEVs and LEVs, the benefits are greater than or approximately equal to the costs.[21]

If California adopts first, other states have reasonably good information (given existing technology) about their own costs and benefits for adopting the same standards. Allowing the states the possibility of adoption is a good idea in theory since it merely adds another potential control strategy to their list of available options. In practice, the fact that states must adopt the entire California package is a big drawback. Moreover, allowing a mechanism for side-payments from California to other states is critical. The central government could play an important role in facilitating these payments. Finally, it should be emphasized that new car standards themselves may not be the most cost-effective way to improve air quality. Incentive based programs such as gasoline taxes or emissions taxes may give the same result (cleaner new cars) but in a more efficient way.

INSPECTION AND MAINTENANCE PROGRAMS

Vehicle inspection and maintenance (I&M) programs provide another interesting case study of the promise and problems of sharing power and responsibility between central and state governments in the US. In the 1977 Clean Air Act Amendments, I&M programs were required by regions not in compliance with national air quality standards, but their implementation was left entirely to the states. Dissatisfaction with the results of state programs during the 1980s led Congress and the Environmental Protection Agency to subject

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[21] The assumptions here about the benefits of reduced emissions are relatively high compared to the range of estimates in the literature.

the programs to rigorous design standards as part of the 1990 Amendments to the Clean Air Act. EPA issued regulations implementing the new I&M policy in late 1992.

Attempts to implement the new regulations have been disastrous. In Maine, Illinois and most recently Maryland, motorists have been subjected to long waits in lines, errors in emissions measurements, and even damage to their vehicles as new I&M programs were begun before states had figured out how to run them. In other states, including California, Virginia, and Pennsylvania, the requirement for a new I&M program has become a major political issue and a focal point of discontent. The furor has forced the EPA to back off on further implementation, at least temporarily, and agree to allow the states more flexibility and perhaps more time in the design of I&M programs.

A. First-Generation I&M Programs

When I&M programs were first introduced in the US in the late 1970s, under the 1977 Clean Air Amendments, Congress was reacting to the emergence of information indicating a pronounced divergence between new vehicle emission certification and actual in-use emissions. At the time, legislators envisioned emission inspection to be a straightforward extension of state vehicle safety inspection programs which had also been mandated by federal legislation. Many states, in fact, responded by tacking the I&M test onto the existing safety inspection.

By design or default, then, Congress was allowing a quite decentralized approach to I&M. States were given almost no requirements and indeed no direction in the design and implementation of I&M programs. I&M was allowed to become a laboratory of state innovation and experimentation. There was, however, this important difference: the states were allowed freedom in their choice of means to achieve a set of goals established by the central government, namely, the achievement of ambient air quality standards. The air quality standard set by the central government was probably stricter than many of the states would have chosen. Some states were simply not as committed to air quality goals, especially when it meant they had to implement a program with highly visible costs. The issue posed by I&M is actually a very common one in the American federal system. It is a principal-agent problem, with the states in the role of agents for the federal government.

The states responded by establishing programs that varied greatly in their effectiveness and in enforcement. Two types of I&M programs emerged in the early 1980s: "centralized" ("test-only") programs, where inspections were conducted at a relatively small number of large specialized facilities operated by the state or by its franchisee; and "decentralized" ("test-and-repair") programs, in which motorists took their vehicles to any of a large number of privately-owned repair shops, garages and auto dealerships certified to conduct emission inspections.[22]

By the late 1980s it had become clear that many of the initial state programs, on which the EPA had placed such high expectations, were not very effective. The EPA concluded that certain features of state programs were causing some state programs to fail and advised Congress to make it difficult for states to continue those features. The lesson drawn by the EPA and Congress from these failures was that it had been a mistake to allow the states such broad flexibility in program design. When the Clean Air Act was amended in 1990, Congress drastically centralized the program, directing the EPA to determine where state programs had

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[22] In principle, one could have decentralized programs that are test-only and centralized programs that both test and repair, but in practice no such programs were developed.

failed and to come up with stringent program guidelines for avoiding or overcoming these failures in the most polluted regions. The new "Enhanced I&M" regulations were to apply to the most polluted nonattainment areas and had to be in place within eighteen months.

Working under this tight deadline, EPA's Office of Mobile Sources hurriedly cobbled together new regulations. These regulations removed much of the flexibility states had for establishing their own programs, and substituted uniform requirements on waiver limits, and on the test procedure and the type of test [*Federal Register* 1992].

Waiver limits existed in most states, to mitigate the financial impact of I&M on individual motorists. Most state programs had a maximum limit on the amount (typically $50 to $75) that would have to be spent to bring a vehicle into compliance. In response to a specific provision of the 1990 CAAA, the new regulations required this waiver limit to be at least $450.[23]

To deal with the apparent inadequacy of emission tests, EPA developed a technically sophisticated emission test protocol that included use of expensive automatic analyzers and a dynamometer. However, it seems likely that EPA vastly overestimated the importance of the test protocol on I&M program performance. EPA's "IM240" test was more accurate than tests then in use in the states, but dynamic simulation of emissions in a fleet of vehicles subject to I&M showed that such an increase in accuracy made remarkably little difference.[24]

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[23] It was clear to nearly all observers that the waiver limits in many states were absurdly low, too low to permit meaningful emission repair. In very few states were the waivers high enough to allow the replacement of a catalyst or oxygen sensor, two components that, once having failed, would have dire consequences for emissions.

[24] Harrington and McConnell, 1994. This study used EPA's own estimates of the "identification rate" and rate of "errors of commission" of various tailpipe tests [USEPA 1992]. The identification rate is the fraction of

Simulation results based on EPA assumptions showed performance far better than any state program was currently experiencing, suggesting that test accuracy was not the critical factor. Even unsophisticated emission tests can identify extremely high emitters, which is where cost-effective emission reductions are found.[25]

Finally, EPA concluded that decentralized test-and-repair programs were less effective than centralized, test-only programs. The new regulations therefore included a provision limiting the emission credits granted a decentralized, test-and-repair program to 50 per cent of the credits available to a centralized program. This was by far the most controversial aspect of the new regulations, because in the states with decentralized programs there were many in the auto repair industry who had become accustomed to and even dependent on the income from those programs and who became a strong and vocal constituency against EPA attempts at centralization.

EPA's reasoning was that mechanics in test-and-repair stations may have incentives that differ from those of the motorist and those of the enforcement agency. On the one hand, they may have an incentive to fail clean vehicles to make repairs that are not really needed. On the other hand, the mechanic may have incentives to pass vehicles that should fail, as a way of ingratiating themselves to customers and assuring repeat business.[26]

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excess emissions detected by an emission test. Errors of commission are complying vehicles incorrectly found in violation.

[25] EPA claims that more sophisticated tests are needed to detect vehicles that have been tampered with [Personal communication, Gene Tierney]. However, EPA never tested the IM240 test against attempts to cheat, so it remains an open question as to whether any regularly-scheduled program can detect cheating reliably.

[26] Centralized programs are presumably impervious to these perverse incentives, although they are of course vulnerable to old-fashioned bribery by motorists. Corruption has been found, for example, in New York's centralized program.

Since 1990 a large number of studies have been carried out that examine more relevant measures of I&M performance and other aspects of on-road emissions. These studies have also begun to suggest why I&M programs may be more difficult to implement than originally thought. First, the pattern of vehicle emissions is much more complicated. While it is well known that vehicle emission rates vary substantially at different conditions of speed and acceleration, it also turns out that emissions of some vehicles vary substantially at different times even at the same stage in the driving cycle [Bishop and Stedman 1994]. This makes it more difficult to determine whether vehicles are consistent violators in a scheduled lane test, and in particular it makes it difficult to determine whether a gross-emitting vehicle has been repaired. Secondly, vehicle emissions are concentrated in a small number of gross emitters [Walsh et al. 1994, Lawson et al. 1990, Lyons and Stedman 1991], such that conventional lane testing of every vehicle inevitably means that most of the vehicles tested are in compliance or nearly so. Thirdly, really gross-emitting vehicles – the tail of the emission distribution – tend to be those that are not well-maintained by their owners [Beaton et al. 1995]. There is a correlation between emissions and age, but probably because older vehicles are not as well maintained as newer ones. Fourthly, vehicle repair is often costly and fails to bring vehicles completely into compliance [Sun Oil Co. 1995, Lodder and Livo 1994]. Also, there appears to be very little relationship between vehicle repair costs and the emission reductions achieved [California I&M Review Committee 1993]. Finally, problem cars belong disproportionately to low-income households, for whom emission repair is difficult [Aroesty et al. 1994].

After nearly 15 years, there is little evidence that I&M programs have been effective at reducing vehicle emissions. Nonetheless, studies continue to show that I&M programs have enormous potential for substantial and cost-effective emission reductions. The gap between the potential and the performance is what keeps I&M an object of keen interest among policy makers.

The US experience with I&M suggests that repetition of the policies that have been tried in the past will not produce effective programs. It is quite clear now what does not work; unfortunately, however, there is much less certainty about what will work. Any successful I&M policy will be one that is largely untested. This means that it is important for EPA to structure a flexible program and one that gives states the incentives to experiment with new approaches. Recent research does suggest some policy designs that may deserve further consideration.

1. Remote sensing

The fact that excess emissions are highly concentrated in a small number of vehicles suggests that it is costly to subject all vehicles to a periodic lane test. The high variability of vehicle emissions, plus the fact that motorist ingenuity has defeated every periodic test so far, suggests that exclusive reliance on more sophisticated lane tests may not be a useful approach. Remote sensing, which can provide test results that are both inexpensive (on a per-test basis) and unscheduled, may be a way of dealing with these problems. Remote sensing programs can be designed in a variety of ways, including combining them with more traditional lane tests.

2. Repair subsidies

The high cost of repair, coupled with the concentration of polluting vehicles in households that can least afford to repair them, suggests that some public assistance for emission repair might be effective. Subsidy policies are always risky, of course, since they can lead to large giveaways of public money and once established, are hard to get rid of. Emission repair subsidies have been opposed in the past for these reasons and also because they could be subject to improper targeting. But no one knows how bad the targeting would be. Old car scrap programs are an alternative to repair subsidies. They can be targeted to the purchase of only the dirty cars by linking them to I&M programs, but they may provide the wrong incentives to car owners.[27] It is possible that the program could suffer some inefficiency and still appear an improvement over current approaches.

3. Emission fees

High and variable repair costs also suggest some form of emission fee. Under a command-and-control approach, vehicles with the same level of emissions are treated equally: if in violation, both must be fixed, even if the cost of emission reduction is much higher on one vehicle than on the other. Emission fees provide the proper incentive so that only one of the vehicles would be repaired. The main practical objection to emission fees has been its demands for accurate quantitative monitoring information, but the better lane tests and the promise of remote sensing may overcome this problem.

Although each of these ideas has promise, they remain untested. No state will try them as long as it will be punished by the EPA for failure. And yet, any state that does try them will be generating information useful to other states. There is a clear role for the central government here, but it is more concerned with encouraging and evaluating experiments than setting rigid standards.

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[27] California is considering a large-scale program that would target polluting vehicles through an I&M

CONCLUSIONS

The strong role of the central government results in more uniform policies, which is a particular problem for ambient ozone where regional variations in ambient ozone are so important. To achieve cost-effective outcomes, allowing flexibility in control strategies is critical. For example, allowing other states to adopt the California new car standards as part of the CAAA of 1990 was a step in the right direction. However, the fact that states or regions must adopt the entire package, which includes extremely tight standards in the future, is a serious drawback. Allowing states the flexibility to adopt only parts of the package may be preferred. For example, only TLEVs may be cost-effective outside of California.

In some cases, allowing flexibility is not enough. It must be encouraged. The I&M program is a good example. Since it is not clear what an effective I&M program looks like, experimentation by the states could have significant payoffs. It can be strongly argued that EPA should encourage such experimentation by backing off from some of the strict, uniform I&M requirements.

This raises one of the most important roles for the central government: devising incentives for states to achieve the desired outcomes. This means that there must be some generally accepted way of measuring performance on the basis of empirical results. It also means that in some cases the central government should give states incentives to experiment in order to gather information about what does and does not work. In other cases, matching grants could be used to reward states for achieving emission reduction targets or air quality

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program and offer owners the option to sell the car in lieu of repair.

goals. Finally, the central government should continue to facilitate cooperation between states when there are spillovers. This could include designing a mechanism for side-payments between winners and losers.

APPENDIX 1

Assume a country with two regions A and B and one manufacturer supplying a product (in this case automobiles) to consumers in both. The welfare consequences of allowing the regions to set emission standards independently to the setting of a uniform standard by the central government will be compared here. So suppose independent standards e_A and e_B, with $e_A < e_B$ (i.e., e_A is more stringent). The unregulated firm has three choices:

(i) Produce one vehicle for sale in both regions, capable of meeting emission standard e_A.

(ii) Produce two distinct vehicles for the two regions.

(iii) Produce one vehicle meeting emission standard e_B and exit the market in Region A.

For simplicity, let it be assumed that in producing each vehicle type the firm incurs a fixed cost of F and constant marginal costs that depend on the design emission level. Thus, the cost function for producing N_A vehicles for sale in Region A is:

$$C(N_A) = F + k(e_A)N_A. \tag{1}$$

Average costs are clearly declining, making the firm a natural monopoly. The price it will charge for each vehicle will be bounded above by the monopoly price, where marginal revenue equals marginal cost. However, its ability to charge at this level might be limited by the possibility of entry by a rival firm. The price is bounded below by average cost. The latter is the competitive case which is discussed in the text above. The firm will be indifferent between (i), (ii) and (iii) above, since it will have the same profits under any of these. Residents in the two regions are not indifferent, and the most likely outcome is two different cars in the two regions. However, as discussed in the text, the welfare maximizing result may or may not occur without central government intervention.

If the firm can act as a monopoly, the results are somewhat different . Suppose the firm is able to charge the monopoly price in each region and let $N_A(p)$ and $N_B(p)$ be the demand curves for vehicles. Suppose that the price elasticities of the two demand curves are the same (at the same prices). To be investigated are the circumstances under which the firm will choose (i), (ii) or (iii) above. Now, (iii) can be eliminated immediately as long as the demand curve $N_A(p)$ in region A lies above the average cost curve at any point. Suppose that is the case. The profit function for (ii) is

$$\pi^2 = p_A N_A(p_A) + p_B N_B(p_B) - 2F - k(e_A)N_A - k(e_B)N_B \tag{2}$$

If ε_A and ε_B are the demand elasticities, then the prices satisfy:

$$-\frac{1}{\varepsilon_A} = \frac{p_A - k(e_A)}{p_A} \text{ and } -\frac{1}{\varepsilon_B} = \frac{p_B - k(e_B)}{p_B} \tag{3}$$

For (i) there is a single market with the same price *p* in both regions, and the demand for vehicles is $N(p) = N_A(p) = N_B(p)$, and the price satisfies:

$$-\frac{1}{\varepsilon} = \frac{p - k(e_A)}{p} \tag{4}$$

At any price, *p*, the single-market elasticity ε is a weighted average of the elasticities in the individual markets. If $\varepsilon_A = \varepsilon_B$ at every price, then both must equal the unified-market elasticity ε. In that case, comparison of (4) and (3) shows that $p = p_A$. In other words, consumers in region A are no better off than they would have been under (ii). But since

$p_A > p_B$, consumers in B pay higher prices for vehicles, although they do enjoy higher environmental quality than they otherwise would have.

As for the firm, its revenues will be lower, and its variable costs higher, when producing for the unified market. However, it does enjoy the possibly greater advantage of avoiding half the setup costs. These costs may be so great that the firm will prefer to make only one type of vehicle to sell in both markets. In this simple model, for the firm to decide to produce only one car, the conditions must be as follows:

$$\Delta = N_B(p_B)[k(e_A) - k(e_B)] - [N_B(p_A) - N_B(p_B)][p_B - k(e_a)] < F \qquad (5)$$

Now consider the possible strategic interaction of the two regional governments in this case. Suppose the standard in each region is initially at level e_B, and region A decides to make its standard more stringent.. The price in region A will increase to p_A regardless of how the firm responds. But in region B the price is affected by the firm's decision to produce one or two cars, and as (5) suggests, that decision is the more likely the smaller the cost difference between the two standards. The only tool that the authorities in region B have to prevent the one-car outcome is to change the standard e_B. To make it more attractive for the firm to produce two separate cars, region B must reduce its emission standard. In deciding whether to take this action, the authorities in B will weigh the advantage of less expensive vehicles against the disadvantage of reduced air quality. In either case, social welfare in B is lower than it was before region A acted. This example suggests that in the case of monopoly, the existence of economies of scale can also lead to spillovers that might justify action by the federal government.

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