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Fundamental Flaws of Social Regulation: The Case of Airplane Noise

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Executive Summary

The growing concern about the cost-effectiveness of social regulations has spurred Senators Fred Thompson and Carl Levin to introduce legislation requiring federal regulatory agencies to conduct a cost-benefit analysis of every regulation with an annual economic impact greater than $100 million. But while this legislation appears to be a step in the right direction, it fails to address an issue that is even more important than the balancing of regulatory costs and benefits.

The fundamental economic criteria for evaluating any public policy is whether it *maximizes* social net benefits. Given that social regulations are, in principle, designed to reduce welfare losses caused by externalities or threats to human health and safety, the first step for regulators is to know whether the (alleged) market failure is sufficiently costly to justify government intervention and whether a proposed regulation is the most efficient way to correct the market failure.

The paper studies the regulatory battle over airplane noise to illustrate how addressing these questions can improve regulatory policy by targeting government action where it is needed. The 1990 Airport Noise and Capacity Act (ANCA) mandated the elimination of certain (Stage II) aircraft at all U.S. airports by the end of 1999. The ANCA therefore affected aircraft design and generated benefits to homeowners who live in areas affected by airplane noise, but it has also generated costs to airlines by reducing the economic life of their capital stock. Surprisingly, analysts have not addressed the basic question of whether the benefits of the ANCA, arguably the most important piece of airplane noise regulation to date, exceed its costs. Our own cost-benefit analysis of the ANCA finds that its $5 billion (present discounted value) in benefits fall considerably short of its $10 billion costs.

More fundamentally, we find that the net benefits that could have been generated even by an economically optimal airplane noise tax amount to only $0.2 billion (present value). Just as the ANCA has done, an optimal noise policy would transfer wealth from airlines and travelers to homeowners—although to a much smaller extent. It appears that current FAA noise regulations have generated substantial costs to society when, in fact, there was little justification on efficiency grounds for any regulatory intervention in the first place. A solid analytical foundation for social regulation will preclude criticism of its cost-effectiveness.

Introduction

Since the turn of the century, and increasingly of late, the U.S. government has engaged in social regulation aimed at controlling externalities—spillovers from ordinary business activity—that compromise or imperil human health and safety. Today, the typical targets of social regulation include pharmaceuticals, workplace safety, product safety, and discharges of pollution. But such regulations have recently come under attack as being excessively costly. Economists estimate that social regulations cost U.S. firms and consumers roughly $200 billion a year while appearing to produce benefits nowhere near that (Hahn and Litan (1997)).

The growing concern about the cost-effectiveness of social regulations has spurred Senators Fred Thompson and Carl Levin to introduce legislation requiring federal regulatory agencies to conduct a cost-benefit analysis of every regulation with an annual economic impact greater than $100 million. But while this legislation appears to be a step in the right direction, it fails to address an issue that is even more important than the balancing of regulatory costs and benefits.

The fundamental economic criteria for evaluating any public policy is whether it *maximizes* social net benefits. Given that social regulations are, in principle, designed to reduce welfare losses caused by externalities or threats to human health and safety, the first step for regulators is to know whether the (alleged) market failure is sufficiently costly to justify government intervention and whether a proposed regulation is the most efficient way to correct the market failure.

The regulatory battle over airplane noise illustrates how addressing these questions can improve regulatory policy by targeting government action where it is needed. After decades of public complaints and legal battles over the noise created by airplane engines, in 1969 Congress gave the Federal Aviation Administration (FAA) regulatory authority to set noise standards for new aircraft designs. In 1977 the FAA established three stages of aircraft noise, and set deadlines to guide the airlines in meeting the (quieter) second-stage noise requirements.[1] The 1990 Airport Noise and Capacity Act (ANCA) mandated the elimination of Stage II aircraft at all U.S. airports by the end of 1999. Unlike earlier noise regulation, which was non-binding (i.e., the FAA believes that most carriers would have replaced Stage I aircraft with Stage II aircraft in pursuit of greater fuel efficiency), the ANCA forces airlines to retire or retrofit roughly 44 percent of their 1990 Stage II aircraft that would have remained in use after 1999 in the absence of regulation.[2]

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[1] For example, the Boeing 707 is a Stage I aircraft, the Boeing 727 and DC-9 are Stage II aircraft, and the Boeing 767 is a Stage III aircraft.

[2] See Federal Aviation Administration (1992a). Airports do not have the authority to regulate noise without the approval of the FAA. Only a handful of airports have noise regulations that specify the noise level of planes.

Thus the ANCA has affected aircraft design and generated benefits to homeowners who live in areas affected by airplane noise, but it has also generated costs to airlines by reducing the economic life of their capital stock. Surprisingly, analysts have not addressed the basic question of whether the benefits of the ANCA, arguably the most important piece of airplane noise regulation to date, exceed its costs. Our own cost-benefit analysis of the ANCA finds that its $5 billion (present discounted value) in benefits fall considerably short of its $10 billion costs.

More fundamentally, we find that the net benefits that could have been generated even by an economically optimal airplane noise tax amount to only $0.2 billion (present value). Just as the ANCA has done, an optimal noise policy would transfer wealth from airlines and travelers to homeowners—although to a much smaller extent. It appears that current FAA noise regulations have generated substantial costs to society when, in fact, there was little justification on efficiency grounds for any regulatory intervention in the first place. If policymakers can assure that social regulation rests on a solid analytical foundation, its critics are all but certain to stop objecting to it on the basis of its cost effectiveness.

The Costs of Noise Regulation

Commercial aircraft have a finite economic and physical life and require replacement at some point. Noise regulations can disrupt carriers' replacement cycle and raise their capital costs if they force carriers to replace a portion of their fleet earlier than planned. The costs of regulations are reflected in the accelerated depreciation of affected aircraft. For example, figure 1 shows that the value of Stage II aircraft, based on a sample of these planes that were built before 1985, declined nearly 20 percent in the year following the announced phaseout of Stage II aircraft in the fall of 1990. Aircraft values did not adjust immediately to the announced phaseout and continued to decline in subsequent years. It is obviously difficult to infer from this figure precisely how much the 1990 Airport Noise and Capacity Act, which mandated the phaseout, contributed to the depreciation of the industry's Stage II aircraft. We therefore develop a simple life cycle cost model to estimate the costs that are attributable to the ANCA. The model rests on the notion that planes are durable capital goods that have revenue-producing capabilities over time. Airlines incur a cost in every time period to maintain their existing capital stock. The effect of the ANCA is to make a portion of an airline's capital stock obsolete, thus raising an airline's cost of maintaining its desired capital stock.

The Model: Carriers can meet the ANCA Stage III requirements by replacing their Stage II aircraft with Stage III aircraft or by retrofitting their Stage II aircraft with "hush kits" so that they comply with Stage III standards. It is reasonable to assume that these costs are comparable because airlines have not revealed a clear preference to retrofit rather than replace. Our analysis will therefore be based on a fleet replacement model.[3]

[3] Carriers' decisions of whether to replace or retrofit their planes depend on whether they have an old or new fleet and how well their current fleet is aligned with the markets they currently serve and the markets they plan to serve. In cases where planes are retrofitted, it is difficult to obtain precise estimates of the cost of noise regulations because these costs not only include the cost of the hush kit and installing it, but due to the increased weight on the plane also

Assume an airline continuously replaces its initial capital stock K_o at a rate d such that $K_t = K_{t-1} = K_o$. In every period, the carrier spends d P_kK_o to maintain an existing capital stock, where P_k is the price of a unit of capital. At a discount rate r, the present value of the lifetime cost of capital to the airline *without noise regulation* is:

$$\int_0^\infty \delta \; P_k K_0 \; e^{-rt} \; dt = \frac{\delta \; P_k K_0}{r} \quad . \qquad (1)$$

How does noise regulation affect a carrier's capital costs? Suppose the regulation is announced in the current period $t=0$ and states that all planes must meet new standards in a given number of years. Let z be the portion of the capital stock that does not meet the standards at the time of the initial announcement, so that z P_kK_o is the initial value of the affected capital stock. Following Jorgenson (1989) and Nelson and Caputo (1997), we assume that the capital stock, including aircraft affected by noise regulations, declines at a geometric rate.[4] The depreciation rate under noise regulation is denoted by a.[5]

The value of the initial Stage II capital stock declines over time as Stage II planes are replaced by Stage III planes. At each time t, a portion a of the remaining Stage II capital stock is replaced. Thus, at a continuous rate of decline a, an amount z P_kK_o $e^{-\alpha t}$ remains invested in Stage II aircraft in each time t. Note there is also a loss in each time t in the value of the Stage II capital stock of an amount α z P_kK_o $e^{-\alpha t}$.

As carriers replace their Stage II fleet with Stage III planes, the value of the Stage III capital stock grows from its initial value of (1–z) P_kK_o. Because the value of the total fleet remains constant, each loss in Stage II value must be offset by a

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include the costs of structural modifications to the aircraft and changes in the aircraft's range, payload, and fuel economy. The costs also include the time the aircraft is out of service. We will provide a rough estimate of these costs to provide a check on our estimate of the cost of noise regulations based on fleet replacement.

[4] The ANCA mandates a schedule for the transition to Stage III planes. Carriers can comply by phasing out Stage II airplanes relative to the number of those aircraft in their fleet on any day between January 1, 1990, and July 1, 1991, or by attaining a given fleet composition by phasing in Stage III airplanes. Under the phase-out option, carriers must reduce the number of Stage II aircraft by 25 percent by the end of 1994, 50 percent by the end of 1996, 75 percent by the end of 1998, and 100 percent by the end of 1999. The fleet composition option requires that 55 percent of a carrier's fleet consist of Stage III planes by the end of 1994, 65 percent by the end of 1996, 75 percent by the end of 1998, 100 percent by the end of 1999. There are modified regulations for new entrants, and extensions to the deadline may be granted in rare cases. These requirements are based on the number of planes rather than the value of the capital stock, which makes direct comparison to economic depreciation rates difficult. It is clear, however, that carriers are gradually converting their fleets to meet interim fleet mix or phase-out standards, and that Stage II planes are fully eliminated from the active fleet by the end of 1999. We thus use the continuous geometric depreciation rate, accepting Nelson and Caputo's (1997) argument that a geometric rate serves as a reasonable approximation of the economic decline of most capital equipment and aircraft in particular.

[5] Note a will depend on how long carriers are given to adapt to the new regulation. A shorter transition time will raise a, a longer transition time will lower a.

comparable gain in Stage III value. Thus the value of the Stage III capital stock in each time t that has replaced Stage II stock is $P_k K_o - z P_k K_o e^{-\alpha t} = (1 - z e^{-\alpha t}) P_k K_o$.[6]

The cost to a carrier of maintaining its fleet under noise regulation may therefore be quite different than it would be in an unregulated environment. Assuming the depreciation rate d without noise regulation applies to the Stage III capital stock and the depreciation rate α with noise regulation applies to the Stage II capital stock, the capital cost to a carrier in time t is

$\alpha (z e^{-\alpha t}) P_k K_o + \delta (1 - z e^{-\alpha t}) P_k K_o = (d + z (a - d) e^{-\alpha t}) P_k K_o$,

and the present discounted lifetime capital costs to the carrier under regulation are

$$\int_0^\infty (\delta + \zeta (\alpha - \delta) e^{-\alpha t}) P_k K_0 e^{-rt} dt =$$

$$(2) \qquad [\frac{\delta}{r} + \frac{\zeta (\alpha - \delta)}{r + \alpha}] P_k K_0 .$$

Thus the increase in the present value of carriers' capital costs due to noise regulation is simply the difference between their costs with regulation (equation 2) and without regulation (equation 1):

$$(3) \qquad [\frac{\delta}{r} + \frac{\zeta (\alpha - \delta)}{r + \alpha}] P_k K_0 - \frac{\delta P_k K_0}{r} = \frac{(\alpha - \delta) \zeta P_k K_0}{r + \alpha} ,$$

which amounts to the difference between the regulated and unregulated depreciation rates, a and d, times the capital stock $\zeta P_k K_o$ that is initially held in Stage II planes, adjusted by a factor $r + \alpha$ to account for discounting and the declining value of the remaining Stage II capital stock over time. This measure does not account for the fact that Stage III aircraft have greater operating efficiency than Stage II aircraft. But because most carriers would not voluntarily adopt Stage III aircraft at the pace mandated by the ANCA, Stage III planes' higher purchase prices exceed the value that carriers place on their greater operating efficiency.

Parameters and Findings

Our data set includes 56 scheduled passenger airlines that at one time during 1977-1995 were operating as a major

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[6] Our findings are not sensitive to exogenous fleet growth. If carriers are growing during the transition, they may find the costs of the regulation easier to absorb because they represent a smaller fraction of their total costs. Nonetheless, the 100 percent depreciation of carriers' Stage II fleet in the year 2000 represents the same absolute loss to carriers regardless of their growth during the transition period.

carrier (annual revenue greater than $1 billion) or a national carrier (annual revenue between $100 million and $1 billion). Data for each carrier's fleet were obtained from Back Associates. The data include the number of aircraft of each type and their year of manufacture as of December 31 for each year. The estimated market value of each of these aircraft for each year was obtained from the Aircraft Appraisal Association of America. We use these data to provide empirical estimates of the parameters that determine the cost of the ANCA to the airline industry.

Portion of the capital stock held in Stage II aircraft in 1990: Based on our data set, we calculate that Stage II aircraft represented 24 percent of the value of the capital stock of U.S. majors and nationals in 1990.[7] Because our data set includes only major and national scheduled passenger carriers, it may not accurately reflect the portion of the capital stock held in Stage II planes for the entire industry, which includes regional carriers, charters, and cargo carriers. The FAA (FAA (1995)) estimates that 55 percent of the planes in the entire industry fleet were Stage II in 1990, which could represent up to 29 percent of the value of the capital stock according to our estimates.[8] Thus we use the mid-point 26.5 percent as our base case estimate, and 24 percent to 29 percent as a range for sensitivity purposes.

Total value of the airplane capital stock: According to our data set, the value of airplanes held by the 30 major and national carriers operating in 1990 was $75.3 billion (1995 dollars). These carriers account for a large fraction, but not all of the industry's airplane capital stock. We thus compared the entire industry's available ton-miles with the available ton-miles accounted for by the major and national carriers in our sample. This comparison calls for the value of airplanes in our sample to be increased 15 percent, which yields an estimate for the entire industry of $86.6 billion (1995 dollars). This figure may represent an upper bound to the extent that major and national carriers' capital stock is more valuable than other carriers' capital stock. A reasonable lower bound estimate would call for the value of airplanes in our sample to be increased 10 percent, which yields an estimate for the entire industry of $82.8 billion. We use the average of these two estimates for our base case, $84.7 billion, and the endpoints for sensitivity analysis.

Interest rate: Because we are analyzing the welfare effects of a public policy, the interest rate should reflect the real social discount rate, which is equal to the real social opportunity cost of capital. This cost of capital can be separated into the risk-free cost of capital and the risk premium. Although real long-run rates of return on Treasury bonds have averaged close to 3 percent,

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[7] The use of 1990 capital stock figures is appropriate because the ANCA was announced toward the end of 1990 and the aircraft market probably did not respond until 1991. If the aircraft market did respond earlier, our cost estimates would be downward biased because less stock would be affected by the ANCA. Stage II aircraft represent 46 percent of the planes in our data set, but only 24 percent of the fleet value because they are older and less valuable, on average, than Stage III planes.

[8] Stage II aircraft represented 46 percent of majors and nationals planes and 24 percent of their fleet value. By maintaining this proportion, we estimate that if Stage II aircraft represented 55 percent of the entire industry's planes, they could account for 29 percent of the industry's fleet value.

real long-run pretax rates of return on equities are much higher. We thus use an interest rate of 7 percent in our base case, which is consistent with the social discount rate that the Office of Management and Budget uses in their assessments, and use a range of 6 percent to 8 percent for sensitivity purposes.

Depreciation rate of planes affected by regulation: According to our data set, from 1991 to 1995, the average annual real depreciation rate for Stage II planes was 22.0 percent.[9] At this rate, the vast majority of the fleet will consist of Stage III planes at the end of the transition period. The Stage II planes left at the end of 1999 will have roughly 3.5 percent of the value of the initial total fleet.[10] Thus our base case assumption of the depreciation rate of planes affected by regulation is 22 percent and we consider a range of 20 percent to 24 percent for sensitivity purposes.

Depreciation rate of planes unaffected by regulation: According to our data set, from 1978 to 1990, Stage II planes depreciated at about the same real annual rate, 4.6 percent, as Stage III planes. From 1990 to 1995, a period of relatively slow growth in air travel, Stage III planes depreciated at a real annual rate of 10.4 percent. It is reasonable to assume that Stage II planes would have depreciated at the same rate as Stage III planes in the absence of regulation.[11] If the depreciation rates since 1995 immediately returned to their historical level of 4.6 percent, the average depreciation rate over the entire transition period would be 7.9 percent. This can be interpreted as a lower bound. Because it is very unlikely that depreciation rates have increased in recent years as growth in air travel has accelerated, a reasonable upper bound is 10.4 percent. We use the midpoint of these two values, 9.1 percent, as our base case and use the endpoints for sensitivity purposes.[12]

Findings: Table 1 presents estimates of the costs of the ANCA based on our assumed values of the parameters in equation 3. We find that the present discounted cost of this noise regulation amounts to $10 billion (1995 dollars) in the base case.[13]

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[9] U.S. airlines own a large portion of the world's Stage II planes. Thus the price for Stage II aircraft is likely to be significantly affected by the noise regulations.

[10] Based on our model, this figure is obtained by calculating the value of Stage II planes remaining after time *t*, $z\, P_k K_o\, e^{-\alpha t}$. We use the transition time between the November 1990 announcement and the end of 1999, 9.167 years.

[11] Noise regulations could lower the depreciation rates of Stage III aircraft even though they were not directly affected by the regulations. But it is doubtful that noise regulations created scarcity value for Stage III aircraft because carriers had several years to respond to the regulations with options such as retrofitting. In addition, the fact that Stage III depreciation rates are substantially higher in the 1990s than they were previously suggests that it is unlikely that they were significantly lowered by the ANCA.

[12] Our base case estimate is close to FAA estimates (FAA (1992a)) that imply a depreciation rate of 8.9 percent would have existed for Stage II aircraft in the absence of regulation. However, the FAA estimate is derived from fleet sizes, so it is not directly comparable to our estimates based on fleet values.

[13] The ANCA forces carriers to sell any remaining Stage II planes for "scrap" value or to foreign countries in the year 2000, which would fully exhaust their initial Stage II capital stock. Because our model assumes that the Stage II capital stock depreciates at a geometric rate, it can never reach zero. As noted earlier, our model implies that roughly

Considering the full range of parameter values yields an upper-bound cost estimate of $13.5 billion and a lower-bound cost estimate of $6.8 billion.[14] To be sure, the airline industry will raise fares in accordance with the supply and demand elasticities for air travel to recoup some of these losses from air travelers. Nonetheless, given that the capital losses represent 34 to 54 percent of the initial (1990) value of the airline industry's Stage II aircraft, and 8 to 12 percent of the industry's entire aircraft capital stock, the costs of the ANCA appear to be substantial.[15]

The Benefits of Noise Regulation

Because noise regulations make the residential environment surrounding airports quieter, their benefits are reflected in higher housing values. We obtain an estimate of the national benefits of the 1990 Airport Noise and Capacity Act by first determining the extent to which it has reduced noise and the value that noise reduction adds to affected homes. We then estimate how many U.S. households benefit from a more valuable home because of this legislation.

3.5 percent of the total initial capital stock will remain in Stage II planes in the year 2000. This capital stock amounts to $2.99 billion, which according to our model is discounted by carriers over an *infinite* time horizon and yields a present discounted cost of $0.70 billion. In fact, carriers must sell their remaining Stage II aircraft for scrap value in the year 2000. If they receive no money for the scrapped planes, they will lose the full present discounted value (from the year 2000) of $2.99 billion, which is $1.57 billion. In this case, our estimate of the cost of the ANCA is understated by $0.87 billion ($1.57 billion - $0.70 billion). If each of the 2,039 Stage II aircraft we estimate to be in U.S. fleets were sold for roughly $670,000 in the year 2000, then the carriers would incur a cost from the ANCA roughly equal to what we find in the base case. An examination of our data indicates that this figure is reasonably close to aircraft values the year before they are salvaged, retired, or sold abroad. Thus. it is unlikely that our estimates of the ANCA are significantly affected by not explicitly accounting for scrap value.

[14] As indicated previously, it is difficult to obtain precise estimates of the costs of noise regulations based on the cost of retrofitting planes with hush-kits. Rough estimates of these costs from industry sources based on the cost and installation of the hush-kit, the extent of aircraft structural modifications and changes in flight operations, and so on suggest that these costs can easily exceed $10 million per plane. We do not know when retrofitting would occur, which makes it difficult to calculate present values, but given that the ANCA requires replacing or retrofitting roughly 1000 aircraft that would remain in service in the absence of regulation, it appears that an estimate of the costs of this regulation based on the cost of retrofitting would be comparable to our base case estimate of the cost of fleet replacement.

[15] We have underestimated the costs of the ANCA because we have not accounted for the fact that the increased costs of acquiring Stage III aircraft generally exceed the value that airlines place on their greater operating efficiency. On the other hand, our estimates are hardly affected if we account for travelers' downward sloping demand curve, which enables carriers to adjust their output in response to the costs imposed by the ANCA. To show this, we first note that the annual cost of the ANCA over 9.167 years is $1.48 billion. This translates into an average cost increase per flight of $204 dollars and a cost mark-up of 1.5 percent ($204/$13,145, where $13,145 is the average cost (in 1995 dollars) of a flight in 1990 without the ANCA in effect, calculated from data in the Air Transport Association 1996 Annual Report). Assuming that average costs equal marginal costs and that travelers' price elasticity of demand is -0.7 (see Morrison and Winston (1995)), output would fall 1.1 percent if carriers passed on the marginal cost of the ANCA in higher fares to travelers. This would reduce the initial value of the carriers' capital stock 1.1 percent, which reduces the present value of the cost of the ANCA to $9.9 billion (1995 dollars).

Noise is measured in decibels (dB), which are defined on a logarithmic scale.[16] An increase of 10 dB corresponds to a 1,000 percent increase in sound intensity and a roughly 200 percent growth in the sensation of loudness. Weighting scales, such as the A-scale (dBA), are frequently used to reflect the greater sensitivity of the human ear to certain frequencies.

The effective perceived noise level (EPNdB) is a measure of noise caused by one aircraft event (takeoff, overhead flight, or landing) and considers the sound pressure, duration, and tone of the event at a given location. The Stage I, II, and III classifications for aircraft are based on measures of the EPNdB from the ground for the take-off, sideline (flyover at 450 meter distance), and approach of different types of planes. A Stage II plane cannot exceed a maximum EPNdB of 102 to 108 dBA for approach (the greatest noise is allowed for the heaviest planes). To meet Stage III requirements, planes on their approach cannot exceed 98 to 105 dBA. Similar requirements are imposed for take-off and sideline noise (FAA (1992b)).

Because the noise level at a given location varies during the day, a cumulative measure of the noise level must be determined. In North America, the most frequently used airport noise index is the day-night sound level (DNL), which aggregates the EPNdBs of overhead flights during a day at a given location, weighting nighttime flights very heavily (FAA (1992a)). Typical ambient noise levels in a residential neighborhood are 44-55 dBA. Our analysis considers neighborhoods that experience noise levels above 65 dBA, which are characterized by the FAA as significantly impacted by noise. The FAA (1985) reports that there are minimal measurable benefits from noise reductions that occur in areas with noise levels below 65 dBA. The transition to Stage III planes as required by the ANCA will lower the noise levels of affected homes by roughly 5 dBA (e.g., homes in the year 2000 that would have been exposed to 70 dBA in the absence of regulation will instead be exposed to 65 dBA). We will use this estimate to construct our benefits estimate.[17]

What is the monetary value of this noise reduction? As noted by Small (1975), the relationship between an externality and property values should be based on estimates of homeowners' willingness to pay. Several authors have used this criteria to estimate hedonic pricing models of the impact of airport noise on the present value of detached houses. Their estimates of homeowners' willingness to pay range from 0.10-1.60 percent per decibel reduction, with many U.S. estimates in the range of 0.5-0.7 percent.[18] Because these estimates do not account for the effects of noise on recreational areas or businesses, we will

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[16] The techniques for evaluating noise levels are discussed at length in Nelson (1982).

[17] Maximum noise levels for Stage III airplanes are 2 to 4 dBA lower than Stage II planes for takeoff, 5 to 8 dBA lower for sideline (flyover at 450 meters), and 3 to 4 dBA lower for approach. These figures indicate that conversion to a Stage III fleet reduces noise in affected areas by 4-5 dBA. This figure is corroborated by the FAA Airports Group estimate that the conversion to Stage III planes reduces overall noise levels in affected areas by roughly 5 dBA from what they would have been in the absence of regulation.

[18] See, for example, Nelson (1980) and O'Byrne, Nelson and Seneca (1985) for estimates of the value of airport noise reduction in the U.S. These studies control for the benefits of living near an airport from increased accessibility. Similar estimates for Canadian homes are obtained by Levesque (1994) and Uyeno, Hamilton, and Biggs

use a value of 1 percent per decibel (i.e., a 1 decibel reduction in the noise level raises the present value of affected homes by 1 percent). Given that the ANCA reduces airplane noise by 5 dBA, we assume that its benefits amount to 5 percent of the present value of affected homes.[19]

We estimate the present value of affected homes from noise exposure maps for 35 major airports, which account for roughly 60 percent of airline operations.[20] We assume that the number of houses within the 65 dBA noise contour in 1990, which the FAA defines as significant noise exposure, is a reasonable approximation of the number of houses in the year 2000 that would have been within that contour in the absence of regulation.[21] The exposure maps are matched with tract-level 1990 census data on median home values, under the assumption that houses are distributed evenly throughout the census tract.[22] This assumption implies that our benefit estimates are biased upward if houses tend to be built in a quieter part of a census tract. For each airport, we calculate the weighted average of median housing values for census tracts that lie wholly or partially within the 65 dBA noise contour.[23] We accept long-standing arguments that current housing prices reflect present values because they incorporate the market's forecast of future developments that might affect these prices.

In table 2, we summarize the benefits of the ANCA and their components for each airport in our sample and find that the present value of benefits for the country amounts to roughly $5 billion (1995 dollars). The national estimate is obtained by assuming that the proportion of airline operations in the country represented by our sample, 60 percent, is equal to the proportion of the value of the affected housing stock in the country represented by our sample. We adjust this estimate to account for the fact that the average value of a home located near non-sample airports has roughly 81 percent of the value of a home located near

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(1993).

[19] We assume that the benefits of noise reduction are a constant percentage of the value of affected homes, a practice that is standard in the literature.

[20] Noise exposure maps are from Noise Compatibility Planning Studies submitted to the FAA by airports participating in the Federal Aviation Regulations (FAR) Part 150 Airport Noise Compatibility Program. FAR Part 150 maintains guidelines for the standardization of submitted maps.

[21] If airport traffic increases during the transition period, then the number of houses within the 65 dBA contour is likely to grow because there are more noisy events. But an offsetting effect is that airlines would be gradually making a transition to quieter Stage III planes even in the absence of regulation.

[22] Census tracts were identified using official 1990 census maps from the U.S. Census Bureau. Housing values were obtained by taking an average of median values of homes in census tracts surrounding an airport, weighted by the number of affected homes (homes within the 65 dBA noise contour) in each tract. Median house values were based on 1990 census data, provided by the U.S. Census Bureau.

[23] In keeping with intergovernmental standards, FAR Part 150 Guidelines consider areas with noise levels of 65 dBA or higher to be impacted by noise, and do not require noise exposure maps to indicate noise contours below 65 dBA (FAA (1985)).

our sample airports.[24] The difference in home values arises because major airports, and thus homes in the sample, tend to be located in the largest (and most expensive) metropolitan areas in the country. The ANCA affects the value of roughly $100 billion of the nation's housing stock, and provides some 800,000 households with an average benefit of more than $6,000. But although these benefits are sizable and widespread, they fall far short of the ANCA's $10 billion costs, resulting in a cost-benefit ratio of 2:1 and casting considerable doubt on the social desirability of this policy.

An Efficient Solution

No one doubts that airplane noise is an externality that imposes social costs. Our assessment, however, indicates that the Federal Aviation Administration's approach to correcting this market failure has done more economic harm than good. But beyond accurately measuring the costs and benefits of a particular regulation, it is also important to consider whether other approaches to addressing an acknowledged problem could generate significant economic benefits. One solution in this case, for example, might be to allow air carriers to make unconstrained aircraft replacement decisions, but to charge them for the cost of soundproofing houses that are affected by noise. This approach, however, does not appear to be promising because the estimated costs of soundproofing, $25,000-$52,000 per house, significantly exceed the roughly $6,000 in benefits per house from reducing airplane noise below significant levels.[25]

The economically efficient regulatory solution—the approach that would maximize social net benefits—is to set a Pigouvian noise tax that eliminates the gap between the private and social marginal costs of airplane flights. The tax is thus the marginal cost incurred by homeowners from an additional flight. To estimate this tax and its welfare effects, it is reasonable to assume that the typical flight contributes about 0.02 dBA to the daily day-night noise level and about 0.000055 dBA to the annual day-night noise level.[26] Because every flight constitutes two events (one departure and one arrival), each flight contributes 0.000055

[24] This estimate is based on a comparison of the average house price for the "place" where the 35 sample airports are located with the average house price for the "place" where 165 non-sample airports are located. These 200 airports account for nearly all U.S. airline operations. A place is defined by the 1990 Census as a population center, usually consisting of at least 1,000 people and identifiable by name. A metropolitan statistical area consists of at least one place (often many), usually with a population of at least 50,000. We used the Census defined place for our analysis because it is typically a smaller unit than an MSA and offers a more accurate picture of housing values immediately surrounding the airport. Our estimate was not perceptibly affected when the average house prices were based on MSAs instead of places.

[25] The cost estimates of soundproofing are based on figures supplied by John Driscoll, Executive Director of the Los Angeles Airport, and from an unpublished study commissioned to analyze airplane noise at Chicago O'Hare airport. Our conclusion is consistent with Gillen (1997), who finds that the costs of soundproofing homes in Denver, Seattle, and Manchester greatly exceed their benefits.

[26] These figures are based on formulae presented in the Federal Aviation Regulations (FAR) Part 150 guidelines. A typical Stage II 727-200 departure, for example, constitutes a 100 dBA event at a house beneath the flight path 5 miles from the airport. An event (arrival or departure) of this type adds roughly 0.02 dBA to the daily noise level at that house, considering the possibility that the event may be a more heavily weighted nighttime flight and the fact that the effective perceived noise levels for arrivals are slightly higher than for departures for a given plane type.

dBA to the annual noise levels of affected houses near two airports. Recall, that we assume that an additional dBA reduces home values 1 percent. Thus to construct a noise tax for each of 200 airports (including the 35 original airports in our sample and 165 others), we assume that each additional annual flight (forever) depreciates the value of affected homes surrounding two airports by 0.000055 percent, which is equivalent to depreciating affected homes surrounding one airport by 0.00011 percent. Assuming a discount rate of 7 percent yields an annualized depreciation of 0.0000077 percent. We find that the average amount (weighted by the number of operations at each airport) by which the marginal social cost of a flight exceeds the $13,145 marginal (equals average) private cost of a flight reported in footnote 15 is $127, for an average mark-up of 1.0 percent.

The net welfare gain to society from imposing an efficient airplane noise tax based on the mark-ups, *m*, at each airport is given by the standard formula:

$\frac{1}{2}\, TR\, e\, m^2$,

where TR is annual airline industry revenues and e is the passenger demand elasticity. We use average annual industry revenues from 1990 to 1995, $88.7 billion (1995 dollars), a demand elasticity of (minus) 0.7, and a weighted average of the square of the mark-ups at each airport to obtain an annual welfare gain of $0.013 billion, or a present discounted welfare gain of $0.184 billion.[27] Note this calculation does not account for any adjustments that airlines would make to their equipment in response to the tax (e.g., buy quieter planes to reduce or avoid the tax). But given that the findings of this paper imply that the costs of quieter planes to airlines exceed their benefits, as reflected in lower tax payments, such a response is unlikely. Because the tax would result in a transfer payment to homeowners from carriers and passengers, homeowners would gain substantially more than $184 million. Nonetheless, the potential social net benefits from efficiently internalizing the airplane noise externality appear to have been quite small from the very start.[28] By significantly overshooting the mark, the FAA has cost society $5 billion.

The estimated welfare gain from an efficient airplane noise policy is small because noise costs represent such a small portion of the social costs of airline travel, which include the operating costs of providing air service and the capital costs of aircraft. Thus air travel behavior is very inelastic with respect to the costs of airplane noise, which suggests that an efficient noise tax would be unlikely to influence traveler and carrier behavior in ways that would reduce airplane noise. This is certainly not the case for all transportation externalities. For example, an efficient automobile congestion toll would represent a moderate fraction of automobile travelers' commuting costs and thus reduce congestion by discouraging some automobile travelers from commuting during peak travel periods.

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[27] The average square of the mark-ups is 0.0004. Note this is greater than squaring the average mark-up.

[28] We do not account for additional benefits from an optimal airplane noise tax that are reflected in new location choices and revised property values. On the other hand, these benefits are difficult to estimate and unlikely to change our qualitative conclusion.

The rational behavior of homeowners may also explain why the potential welfare gains from an efficient noise tax are small. People often take measures to minimize the cost of externalities without any prodding from the government. For example, Calfee and Winston (1998) point out that commuters try to minimize the costs of automobile congestion by living closer to work, using public transit, commuting during off-peak travel periods, and so on. In the case of airplane noise, it would be expected that people who have a high tolerance for noise would be willing to live closer to a flight path and require less compensation, in terms of lower housing prices, than people who have a low tolerance for noise.

The ANCA imposed particularly severe costs on carriers because it influenced production decisions *ex post*, after long-run investments in Stage II planes had been made. Thus the overwhelming fraction of the ANCA's cost to society is incurred in the value of lost capital investments.[29] Given the magnitude of these costs, both carriers and homeowners would probably have been better off if air carriers (or airports) had the option to pay homeowners for the right to fly Stage II planes.[30]

The ANCA also took a far too broad-brush approach to airport noise and did not recognize that changes in the air travel market affect airports in different ways. For example, in an effort to stimulate airline competition some policymakers are suggesting that additional take-off and landing slots be made available at Washington's Reagan National and Chicago's O'Hare airports. This proposal has prompted complaints that airplane noise would increase. While the complaints are legitimate, current federal airplane noise regulation is silent on this issue because it simply requires industry fleets to meet Stage III noise requirements.

Fundamental Flaws of Social Regulation

If our assessment of the 1990 Airport Noise and Capacity Act focused just on the benefits provided to homeowners, it would be difficult to find fault with the FAA's policy toward airplane noise. But sound public policy must be based on both costs and benefits, and using this standard it is difficult to justify the ANCA. Even more fundamentally, the maximum net benefits that society could accrue from an efficient policy toward airplane noise appear to be quite small.

These sharp conclusions are illustrative of the flaws of many social regulations. Hahn and Hird's (1991) synthesis of previous assessments of social regulations reveals that most studies tend to offer fragmentary evidence on either costs or benefits, but not both, and rarely attempt to estimate the net benefits that could be obtained from an optimal policy. Nonetheless, in areas such as occupational health and safety, consumer product safety, and drug approvals, the costs of social regulations appear to

[29] The costs of the ANCA would have been lower if carriers had been given a longer transition time to meet the Stage III requirements.

[30] Property rights were assigned by a 1962 Supreme Court decision (Griggs v. Allegheny County), which made airport owners liable for noise damages awarded to property owners.

exceed their benefits. Because in many cases the gross benefits of even an optimal policy appear small, it is not likely that significant net benefits could be generated under any circumstances. The net effects of automobile safety regulations are more controversial, but even optimal automobile safety regulations would be unlikely to produce large net benefits. By contrast, both the costs and benefits of environmental regulations appear to be high, resulting in negligible realized net benefits from current policies, but suggesting that it might be possible for policy makers to generate sizable net benefits by setting optimal environmental regulations such as efficient pollution taxes.

From a political point of view, social regulations may be doing what they are intended to do; that is, the magnitude of transfers may be a better indicator of a social regulation's political attractiveness than its efficiency improvements. But the political climate may be changing, as evidenced by the current debate over regulatory reform that clearly recognizes that the costs of many social regulations exceed their benefits. Still, increasing calls to require proposed regulations to pass a cost-benefit test fail to address the fundamental weakness of most social regulations. Even if they pass this test, they may not significantly improve on the market's ability to reduce the cost of potential market failure. A social regulatory policy designed to maximize net benefits would likely result in far fewer social regulations, but those regulations may gather greater political support and significantly benefit society.

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