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Notes and comments

The economic valuation of train horn noise: A US case study

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Abstract

This paper provides a property value-based estimate of the dollar cost of train horn noise in a residential neighborhood in a small town, Wormleysburg, Pennsylvania, US. Residential property values are found to decrease by about $4800, or 4.1%, per 10 db of added noise exposure, for an aggregate total of $4,088,799 in 2004 dollars. The primary study was supplemented with information from a neighborhood survey. Dollar value estimates of train horn costs could prove useful in facilitating balanced benefit-cost analyses of horn noise abatement policies such as quiet zones, wayside horns, underpasses, or street closures.

1. Introduction

The elimination of train horn noise is the primary benefit to be derived from the establishment of quiet zones for railroads. While the long period of experimentation with quiet zones led to a great deal of information about their effects on safety (Federal Railroad Administration, 1995, 2000; Zador, 2003), the benefits of the elimination of train horn noise have received very little attention beyond studies of residents' annoyance levels (Gent et al., 1998). Therefore this paper may begin to fill a need in the analysis of train horn noise and quiet zone policy decisions.

This paper is derived from a more general benefit-cost analysis of a proposed highway-rail underpass in a residential neighborhood in Wormleysburg, Pennsylvania, a small town directly across the Susquehanna River from Harrisburg. Wormleysburg is divided into a narrow 100 year flood plain near the river and a more elevated section to the west, and into northern and southern sections by a local limited access highway. The rail tracks are somewhat elevated relative to the riverfront neighborhood but are well below the crest of the bluff that leads to the western side of the town. Based on a survey of Wormleysburg residents, the riverfront area is highly impacted by train horn and other noise, while most of the higher elevation area is not.

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2. Resident survey

While the primary estimate of the dollar cost of train horns is based on an analysis of property values presented later, the study also benefits from the findings of a survey distributed to Wormleysburg residents in the summer of 2005. This survey asked about perceived loudness and annoyance levels from train horns and train movement, the impact of horn noise on daily activities such as sleep and outdoor activity, and a hypothetical question regarding residents' willingness to pay to eliminate train horn noise. Identifying variables included location, household size, and tenure. Just over 100 questionnaires were returned, the majority of which were from the northern riverfront and uphill neighborhoods in Wormleysburg closest to the rail crossing. The results are consistent with expectations. Annoyance is closely related to perceived train horn volume. Annoyance levels are far higher in the riverfront north area nearest to the rail crossing, higher for train horns than for train movement, higher for those with fewer years of residence, and higher at night than during the day.

The Wormleysburg resident survey also included the following:

> "This question is not about a real person or a real situation and does not mean you will actually have to pay to stop horn noise. Your best guess will be perfectly acceptable. If you could pay some person or group to stop all train horns, what is the most you would be willing to pay per month?"

While the question seems to invite high responses, response biases existed in both directions. At least half a dozen respondents with high or extremely high levels of annoyance offered a zero payment response. The majority of these few respondents added notes saying that while they were annoyed by horns, someone else should pay for their elimination. On the other hand, two respondents offered dubiously high valuations of $500 and $1000 per month, possibly in an attempt to influence the results. Eliminating both groups reduced the average monthly willingness to pay from $30.18 to $13.06 per household, a more reliable figure. Because statistical tests found no correlation between family size and respondents' willingness to pay, these responses were interpreted as individual valuations. Therefore, household values were calculated by multiplying the willingness to pay by the number of adults in the household.

Selected annoyance values and monthly willingness to pay by location are presented in Table 1. The positive relationship between respondents' willingness to pay and train horn annoyance levels, measured on a 5 point scale, is clear. The correlations between willingness to pay and annoyance were 0.612 for daytime annoyance levels, 0.637 for evening and nighttime annoyance levels, and 0.671 for frequency of sleep loss. Correlations between willingness to pay and loudness were 0.590 for daytime and 0.600 for night time. All were highly significant. Average monthly household willingness to pay varied from $66.75 for those with at least one annoyance level of 5 (extremely annoying) to $0 for those households with a highest annoyance level of 1 (not annoying).

Because of the possible upward bias in the survey results, no aggregate dollar value is reported here. The important finding from the survey is the strong correlation between perceived noise volume, annoyance, willingness to pay, and proximity to the Wormleysburg railroad crossing. This information helps to support the indirect sound figures used in the following property value estimate of horn noise costs.

Table 1
Monthly willingness to pay to eliminate train horns

Area	Number of responses	Average night noise rating (5 point scale)	Average night time annoyance rating (5 point scale)	Household willingness to pay
Riverfront north	17	**4.00**	4.06	$55.29
Riverfront south	8	2.94	3.00	21.25
Uphill north	29	**2.56**	2.23	5.21
Uphill south	9	3.50	3.58	30.00
Total	63	3.21	3.12	$24.30

3. Train horn noise and property values

One approach to providing a dollar estimate for the cost of noise uses regression analysis to estimate the one time increase in property value due to the elimination of a noise source. This study utilizes a set of 192 residential properties in Wormleysburg sold between 1980 and 2004. Sales prices were adjusted for housing price inflation using the housing price index for the Harrisburg metropolitan area. In addition to the property's estimated exposure to horn noise, other variables such as lot size, living space, the age of the dwelling, and access to a river view were included as control variables.

Because no sound equipment was available to test train noise directly, a noise distribution map from an Iowa study (Gent et al., 1998) was adjusted to scale and overlaid onto a map of Wormleysburg for northbound and southbound trains. These overlays are shown in Figs. 1 and 2. Gent et al's maps give a visual representation of the resulting sound pattern, and may not be entirely accurate.

Because the Norfolk Southern tracks in Wormleysburg lie partway up a relatively steep hill, sound exposure seems to be pervasive across the riverfront section but relatively negligible for the uphill neighborhood to the west. To test the significance of this topographical issue, the sound distribution overlays from the Gent study were interpreted in three ways. The first interpretation was to make no topographical adjustment in the estimated noise exposure. The second interpretation limits assumed noise exposure to those streets at the river level or above but directly contiguous to the Norfolk Southern tracks. This exposure area is referred to as riverfront plus. The third interpretation limits assumed noise exposure to riverfront blocks only. The (literally) narrower interpretations of sound exposure provide far more significant results than the unadjusted data.

3.1. Property value results

The effect of horn noise on property values was analyzed through multiple regression analysis. Results are shown in Table 2. Results in the uppermost rows indicate that the riverfront and riverfront plus contiguous

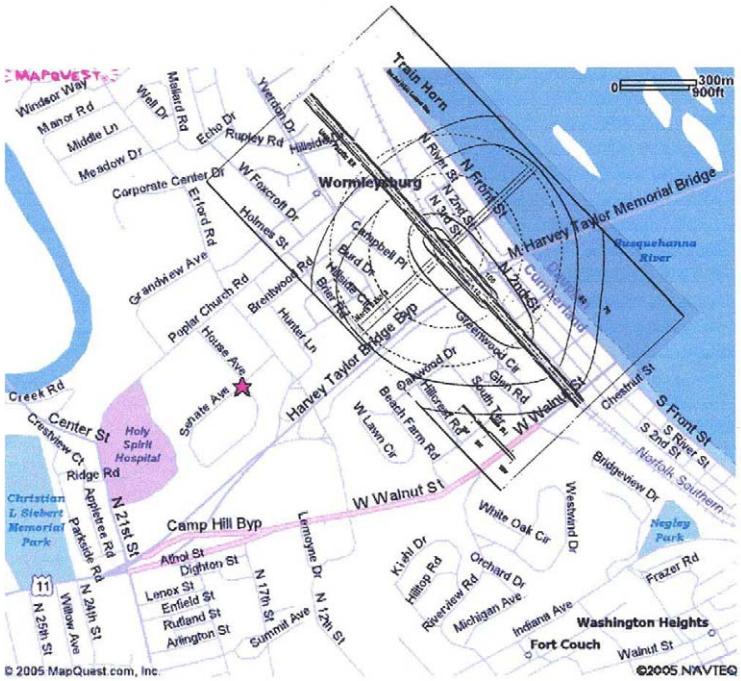

Fig. 1. Northbound Trains.

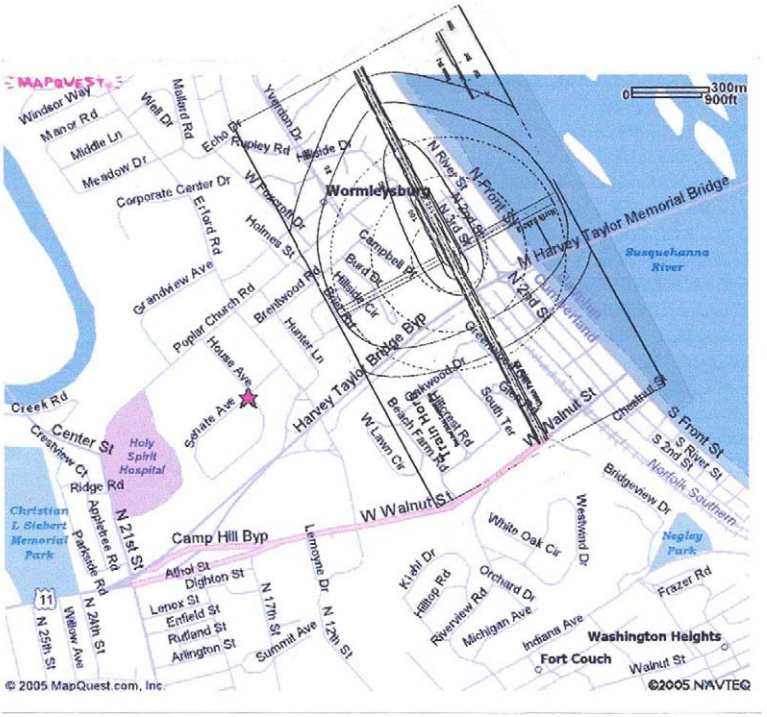

Fig. 2. Southbound Trains.

Table 2
Horn noise effect on real property values[a]

Equation	River level	River level	River plus	River plus	Unadjusted
Constant	146,750	162,036	156,030	172,434	141,102
	(8.56)	(11.368)	(8.12)	(10.29)	(6.22)
Max. horn noise	−4831	−5103			
(River level only)	(−2.213)	(−2.34)			
Max. horn noise			−4,741	−4,837	
(River level plus)			(−1.96)	(−1.99)	
Max. horn noise					−797
(unadjusted area)					(−.257)
Living area	12.085		13.06		13.206
	(1.59)		(1.72)		(1.71)
Acreage	93,814	117,714	86,867	112,956	100,242
	(3.62)	(5.55)	(3.25)	(5.12)	(3.84)
Age of house	−847	−859	−951	−967	−898
	(−5.18)	(−5.23)	(−5.66)	(5.74)	(−4.83)
River view	55,411	61,786	53,802	60,714	55,808
	(5.29)	(6.36)	(5.09)	(6.183)	(5.25)
R^2	0.558	5.52	0.555	0.548	0.546
Adjusted R^2	0.546	5.42	0.543	0.538	0.534

[a] *t*-statistics are in parentheses; all coefficients are in 2004 dollars.

hillside properties experience significant losses in property values. The average residential property in the riverfront or riverfront plus zones lose between $4700 and $4800 dollars of sales value for each 10 db of horn noise exposure above an assumed background level of 50. In the noise exposure zone, properties have an average sales price in 2004 dollars of $115,953. All else equal, the estimated decrease in property value for exposure to each 10 db above background level is 4.1%. Therefore the residents of the 90+ db area will gain an average

16.6% from the elimination of horn noise, with lesser exposure producing correspondingly lower effects. For all 256 riverfront plus residential properties in the affected zones, the aggregate loss of property value from train horns is estimated to be $4,088,799 in 2004 prices.

Tests of non-linear relationships, including a double log specification and squared noise values, produced less significant results, indicating a linear relationship between added noise exposure and property value. The results for other variables are significant and consistent with expectations in size and sign. A high correlation between living area and acreage did not significantly affect the results, as columns 3 and 5 in Table 2 demonstrate.

There are three possible biases in these estimates. On one hand, horn noise may be more widely dispersed than is indicated by our noise maps. Evidence from the Wormleysburg resident survey indicates that residents to the south of the estimated noise zones also may be annoyed by train horns, although the noise zones do extend somewhat into the southern neighborhoods. Secondly, limited data on factors affecting housing value might mask the possible effect of train horns on property value in the newer and more affluent uphill neighborhoods. However, the resident survey indicated low annoyance levels and low willingness to pay for silencing train horns in this uphill area. The final bias is the lack of any separate measurement for other negative effects of trains, such as movement noise. Efforts to test variables indicating proximity to the tracks well south of the highway intersection produced inconsistent results. If part of the estimated effect of train horns is caused by other rail-related factors, then the estimate is biased upward, all else equal. Given these offsetting biases, the estimated aggregate lost property values seems reasonable.

4. Conclusions

Access to a dollar valuation of the cost of train horn noise will allow a more balanced analysis of the net benefits of quiet zones, stationary horns, underpasses, or other horn noise reduction methods. This paper attempts to provide such an estimate using a property value or revealed preference method, supplemented by a resident survey. According to these estimates, the property value effect of train horns averaged approximately $4800 per 10 db of added noise exposure, or 4.1% of the sales value. For all of the 256 affected residential properties, this totaled just over $4 million in 2004 prices. The Wormleysburg resident survey verified a strong connection between horn noise volume, annoyance, willingness to pay, and location, providing support for the indirect sound estimates use in the property value study.

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