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## **The Effect of Noise Barriers on the Market Value of Adjacent Residential Properties**

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This paper provides the first study on the impact of noise barriers on the price of adjacent houses based on a repeat sale analysis (RSA). RSA allows us to empirically examine the differential between the prices of houses sold before and after an event that may have affected their value, and after other relevant variables such as the evolution of the real estate market and major renovations performed on the house are controlled. This paper focuses on the neighborhood of Laval, a suburb of Montreal, where a large noise barrier was built in 1990 along a highway. The data set contains transaction information on 134 houses that were sold at least twice from 1980–2000. The empirical result will show that the noise barrier induced a decrease of 6% in the house prices in our sample in the short run, while it had a stronger negative impact of 11% in the long run.

### **Keywords**

noise barriers; housing market; repeat sale analysis

### **Introduction**

Quality of life is a growing preoccupation in our society. People are increasingly concerned about the level of noise in their environments. Thus,

it is not surprising that an increasing investment has been made in noise barriers in recent years.<sup>1</sup> In order to determine whether this investment contributes to increasing a society's welfare, one has to be aware of all its effects. In general, noise barriers are efficient at reducing the level of noise (Ouimet, 1994), but they have other consequences, such as affecting the prices of adjacent houses. It is well established that an increase in noise levels leads to a decrease in the price of houses (for a recent survey, see Boardman, et al., 2005), so a reduction in noise should have the converse effect. However, some people have argued that the aesthetic impact of walls, or their impact on luminosity, could lead to reduced property values, especially for houses located very close to the shielded dwelling (Kamerud and von Buseck, 1985). Therefore, altogether, the net effect of a noise barrier on the price of adjacent houses is theoretically ambiguous, and has to be resolved empirically.

To our knowledge, only two existing papers have tackled this question, but, as we will show below, none of them has done so in a proper fashion nor reported unambiguous results. This paper is the first study on the impact of noise barriers on the price of adjacent houses based on a repeat sale analysis (RSA), arguably the best methodology for addressing this question. In an RSA, one seeks to identify the impact of an event on the price of houses sold before and after the event. If there is a significant change in prices between the two transactions, this may be attributed to the event. Of course, for that to be true, the researcher must have controlled for other changes that may have had an effect on a house's price between two sales, such as the evolution of the real estate market and major renovations performed on the house. In the past, RSA was used to determine the impact of the construction of a train station (Gatzlaff and Smith, 1993), a highway (Palmquist, 1982), or the discovery of a toxic site (Kohlhase, 1991; Mendelsohn, et al., 1992), on the value of adjacent houses, but it has never been used to evaluate the impact of a noise barrier.

We collected our data from the neighborhood of Laval, a suburb of Montreal, where a large noise barrier was constructed in 1990 along a highway. We were able to obtain information on 134 houses sold at least twice from 1980–2000. In addition, we were able to obtain data on the real estate market in the area for the whole period, as in most RSAs, but also on the demographic characteristics of the area and major renovations carried out on these houses throughout the time span. To our knowledge, this was one of the first times that information on major renovations was available for an RSA, allowing us

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<sup>1</sup> For instance, Statistics Canada (1998) reported a 10% increase in Canadian annual investment in noise barriers between 1995 and 1998. The U.S. Department of Transportation reports that it spent, on average, \$169 million per year on noise barriers from 1995 to 2004, compared to \$108 million in the preceding decade (U.S. Department of Transportation, 2006a).

to conduct an “augmented” RSA.<sup>2</sup> We concluded that the noise barrier induced a decrease of 6% in house prices in our sample in the short run, and 11% in the long run.

The rest of this paper is organized as follows: Section 2 presents a survey of existing studies on the impact of noise barriers. Section 3 discusses our empirical strategy and data. Section 4 presents our empirical results. Section 5 concludes.

## **A Survey of the Existing Literature**

As mentioned earlier, there is a general consensus in the literature as to the negative relationship between the noise level and the price of adjacent houses. Most of the studies that have tackled this question have used the hedonic pricing method. This method implies that regressions are run when the price of a house is related to a vector of characteristics (physical characteristics of the house, market conditions, and neighborhood), including a variable capturing a certain environmental attribute, such as the noise level. Recent surveys (e.g., Boardman, et al., 2005) reported a “noise depreciation sensitivity index” of around 0.65, which means that if the noise level increases by one Noise Exposure Forecast (NEF), then the price of an affected house decreases by an average of 0.65 percent.

Some authors (Palmquist, 1982; Mendelsohn, et al., 1992) have criticized this method, arguing that with samples of houses from different neighborhoods, it is difficult to distinguish between the effect of any environmental attribute on the price of adjacent houses and the effect of unobserved characteristics on that price (e.g., criminality in the neighborhood). These authors have suggested a variant of the standard hedonic pricing method, or the RSA we described above. Using methodologies along these lines, the authors of two papers have looked specifically at the impact of noise barriers on the price of adjacent houses. We will describe and comment on them below.

Kamerud and von Buseck (1985) studied two sites — Troy Meadows and Lakewood, both located near the same highway in Michigan, USA. In 1974, a natural sound barrier (earth berm) was built at Troy Meadows, and this led to real noise reduction estimated at 6 or 7 decibels for residents in the first row. The authors proposed three exercises:

1) Examining the impact of noise on house values in Lakewood, with noise

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<sup>2</sup> As far as we know, only Mendelsohn, et al. (1992) and Case and Quigley (1991) had access to improvement data.

being approximated by the distance between a house and the Interstate;

2) Performing the same exercise for Troy Meadows before 1974, with noise being approximated by the row in which a house is located; and

3) Performing the same exercise for Troy Meadows after 1974 (i.e., after the wall was installed).

The authors' hypothesis was as follows: prior to 1974, with all other things being equal, houses in the first row at Troy Meadows had to sell for less than houses in the other rows, owing to the noise level. After 1974, this price differential between the rows should have narrowed, since the noise barrier should have made the houses in the first row less unpleasant.

The general model used by the authors is expressed by this equation:

$$\log(\text{PRICE}) = \alpha + \beta \cdot \text{SIZE} + \gamma \cdot \text{YEAR} + \delta \cdot \text{LOCATION} + \varepsilon \quad (1)$$

where PRICE indicates the amount of the sale; YEAR refers to the year of the sale (this variable having been introduced to capture general market trends); SIZE is defined as the surface area of the house; and LOCATION is the distance between the house and the Interstate, which captures the noise level. For Troy Meadows, 47 transactions were used in the first estimate before the wall was built, while only 24 were used after its construction (between 1975 and 1980).

The results indicated that prior to 1974, houses in the first row sold, on average, for 4% less than those in rows 2 to 4 and 9% less than those in row 5. After 1974, the price differentials among the rows remained the same. The authors concluded that the wall had no impact on house prices. A number of reasons may lie behind this somewhat surprising result. For instance, according to a survey of residents, the wall had a downside. Some people complained about the unattractive layout, the lack of maintenance (weeds) and the presence of bikers drawn by the mound. So it was possible that these negative effects partially offset the benefits of the wall.

At least three major criticisms could be raised concerning this study. First, the statistical result that led to the conclusion that price differentials among the rows did not change after the wall was built was only 85% reliable. If, like most statisticians, we considered this coefficient to be no different from zero, the conclusion of the study would be quite different: the price differential between houses in row 1 and those in rows 2 to 4 would have vanished, and that would imply that the noise screen actually led to an increase in the relative value of the houses in row 1. Second, the number of control variables (YEAR, SIZE) was very limited compared to what we found in the rest of the literature, where many other aspects were

documented (the presence of a garage, finished basement, etc.). So, it is possible that the estimated coefficients were biased, as a result of this missing information. Third, the number of observations (24) for the regression conducted with transactions after the wall was built was very low.

Hall and Welland (1987) essentially asked the following question: Is the relationship between house prices and the number of decibels affected by the presence of a noise barrier? In other words, does an additional decibel have a smaller or greater impact on a house buyer in a barrier-setting than in a setting without a barrier? With all other things being equal, if a noise barrier means an additional decibel and a negative impact on house prices, which would be even lower if there was no barrier, one may indirectly conclude that the barrier makes noise less “detrimental” to property prices. Hence, this study tests whether the relationship between house prices and the number of decibels is linear or non-linear.

For their exercise, Hall and Welland proceeded as follows. First, they estimated the relationship between noise levels and house prices in three Toronto-area districts where there were noise barriers (Victoria Park, Etobicoke, and Leslie Street). They then compared the results obtained with those of Nelson (1978), who listed studies conducted in settings without noise barriers (an average of -0.4% per decibel), with those of another study conducted by Taylor, et al. (1982) in a part of Ontario with no barriers (\$0.505/decibel).

The methodology they used is similar to that employed by Kamerud, et al. (1985). Hall and Welland obtained data covering about 100 transactions per site, estimated each of the sites, and then combined these for a final estimate covering all three sites. The results for the first two sites (Victoria Park and Etobicoke) were slightly lower than those obtained in the rest of the literature (-0.34% in Victoria Park and -0.39% in Etobicoke). This prompted them to conclude that, “this may be partial evidence that the noise penalty is lower at barrier sites than at sites without barriers; that is barriers matter...” (p.11). Nonetheless, the results obtained at the third site (Leslie Street) were very high, compared to all the studies that were conducted on the question (-2.1%). Consequently, the results of the estimates made for all the observations (-0.76%) were close to those in the rest of the literature.

The size of the impact of the wall on house prices therefore depends on the weight one gives to the estimate made with the data from the third site. Hall and Welland tended to believe that a statistical anomaly was involved, and that only the results from the first two sites should be used. If this is so, the relationship between noise and house prices would be lower at barrier sites than at sites without barriers, and this indirectly suggests that noise barriers enhance property values. Nonetheless, the authors ended their study with

this note (p.11): “That must remain speculation; the data are certainly inadequate to provide a clear test of that suggestion.”

From a technical standpoint, we feel this study is superior to that of Kamerud and von Buseck despite the statistical anomaly it appears to contain. The database used was more complete, and the number of observations was still sufficient to obtain reliable estimates. However, the impact of noise barriers remained a risky one. Compared to other studies conducted in a completely different context, this one was a hazardous exercise.

## Empirical Strategy and Data

Examination of the two existing studies on the effect of noise barriers on the market value of adjacent residential properties led us to adopt the RSA methodology. Following the literature on RSA, in particular Palmquist (1982), Kohlhase (1991), Case and Quigley (1991), and Mendelsohn, et al. (1992), we estimated the following model in which the dependent variable is a price differential:<sup>3</sup>

$$\begin{aligned} \ln P_s - \ln P_f = & \left( \sum_{i=1}^k \beta_{is} Z_{is} + \sum_{i=1}^{\ell} \alpha_{is} Y_{is} + \sum_{i=1}^m \delta_{is} X_{is} \right) \\ & - \left( \sum_{i=1}^k \beta_{if} Z_{if} + \sum_{i=1}^{\ell} \alpha_{if} Y_{if} + \sum_{i=1}^m \delta_{if} X_{if} \right) \\ & + \omega_i \cdot DISTANCE_i + Y_i DISTANCE_i^2 + \varepsilon_i \end{aligned} \quad (2)$$

where the index, s, refers to the second sale of a given house in a pair of transactions, and the index, f, refers to the first sale. P represents the sale price of the house. Z is a vector of variables capturing the existence of the wall and the period during which it was built. The vector, Y, refers to economic and socio-demographic factors, such as the general real estate market price index, which might have affected the price of the house between the two sales. The vector, X, represents the different characteristics of the house, which might have changed (through renovations) between the two sales. As suggested by Kohlhase (1991), we included two variables regarding the DISTANCE of the house from the wall, and  $\varepsilon_i$  as an error term. As one can see, we expressed the independent variables in differentials except for the distance variables from the wall, which are constant through time. Note also that a typical RSA would include only the vector, Z, and a variable, usually a price index, to capture the evolution of the housing market. In actuality, we performed an “augmented repeated sale analysis,” as recommended by Dombrow, et al. (1997), and summarized the definitions

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<sup>3</sup> Actually, this equation is equivalent to Equation (3) of Mendelsohn, et al. (1992), except for the DISTANCE variables.

of the variables in Table 1. Descriptive statistics for all variables (in differentials) are provided in Table 2. There was an average price increase of more than C\$22,000 between the two sales.

**Table 1: Definitions of variables**

Variables	Definition
<b>Variables capturing the existence of the wall</b>	
PRICE	The sale price of the house
BARRIER	Dummy (1, 0) reflecting the existence of the noise barrier at the time of the transaction
CONSTRUCTION	Dummy (1, 0) if the sale occurred during the period in which the wall was built
DISTANCE	The distance of a house from the noise barrier (in meters)
<b>Economic and socio-demographic variables</b>	
PRICE INDEX	The monthly average value of a house sold in the area, according to a private real estate broker index
INCOME	Average level of income in the area
<b>Changing characteristics of the houses</b>	
AGE	The age of the house in years based on its construction date
RENOVATIONS	The cumulative sum of money spent for any kind of renovation
TYPICAL EXTERNAL	The cumulative number of usual external renovations
MAJOR EXTERNAL (V)	The cumulative number of major external renovations
MAJOR INSIDE	The cumulative number of major inside renovations
INGROUND POOL	Installation of an inground pool
TYPICAL EXTERNAL (V)	The cumulative value of usual external renovations
MAJOR EXTERNAL (V)	The cumulative value of major external renovations
MAJOR INSIDE (V)	The cumulative value of major inside renovations
INGROUND POOL (V)	The value of the installation of an inground pool
INFRACTION	The number of infractions of the municipal building code detected by inspectors

V: Value

In the vector,  $Z$ , we first found BARRIER, a dummy variable reflecting the existence (or a lack thereof) of a noise barrier at the time of the transaction. As discussed earlier, the expected sign of this variable was ambiguous. Through noise reduction, the barrier should have helped increase the prices of adjacent houses, which could be counter-balanced by characteristics such as the aesthetic impact, so that the net effect has to be resolved empirically. In line with this argument, Ouimet (1994) indicated that the noise level was reduced by 18% following the introduction of a barrier. Yet, 70% of the respondents to a survey conducted in the area noted that there was a deterioration in their visual environment, and 41% reported a loss of sunlight. Similarly, in a recent study, the U.S. Department of Transportation (2006b) noted the following negative comments in its surveys of residents living near a noise barrier: “restriction of view, feeling of confinement, a loss of air circulation, a loss of sunlight and lighting, and poor maintenance of the

barrier” (p.10).

**Table 2: Descriptive statistics**

Variables (in differentials)	Average	Minimum	Maximum	Standard deviation
<b>Variables capturing the existence of the wall</b>				
PRICE	22,640.35	-105,000.00	126,440.00	37,443.09
BARRIER	0.54	0.00	1.00	0.50
CONSTRUCTION	0.03	-1.00	1.00	0.36
DISTANCE *	130.97	8.00	315.00	98.79
<b>Economic and socio-demographic variables</b>				
PRICE INDEX	23.43	-1.91	60.73	17.14
<b>Income</b>				
INCOME	18,421.15	0.00	42,210.00	13,892.23
<b>Changing characteristics of the houses</b>				
AGE	6.60	0.00	19.00	4.48
RENOVATIONS	1,428.36	0.00	75,000.00	6,510.97
TYPICAL EXTERNAL	5.63E-02	0.00	2.00	0.29
MAJOR EXTERNAL	0.10	0.00	2.00	0.36
MAJOR INSIDE	2.949E-02	0.00	2.00	0.24
INGROUND POOL	5.362E-03	0.00	1.00	7.313E-02
TYPICAL EXTERNAL (V)	270.39	0.00	25,000.00	1,702.86
MAJOR EXTERNAL (V)	1,000.00	0.00	57,000.00	5,227.91
MAJOR INSIDE (V)	163.74	0.00	25,000.00	1,418.58
INGROUND POOL (V)	58.98	0.00	17,000.00	804.39
INFRACTION	0.02	0.00	3.00	0.22

\* All the variables except DISTANCE are expressed in differentials.

V: Value

Another dummy variable, CONSTRUCTION, captured the period, from May 1990 to August 1991, during which the wall was built. Again, the expected sign was not clear. The disturbances due to the construction of the wall could have influenced the price negatively, while the expected noise reduction due to the wall might have had the converse effect. In the same vein, the expected sign of the coefficient of the DISTANCE variable was ambiguous, since the closer one is to the wall, the more likely one will benefit from the noise reduction, while suffering more from the visual impact. Also, as noise attenuates non-linearly, we should include a squared variable.

The vector, Y, capturing economic and socio-demographic factors, contained three variables. PRICE INDEX captured the evolution of the housing market in the Laval-des-Rapides district.<sup>4</sup> Of course, the expected sign was positive. We also included the socio-demographic variable, INCOME,

<sup>4</sup> The source for the PRICE INDEX was Royal LePage, a large real estate agency which calculates price indices for many areas of Canada on a monthly and an annual basis. The Price Index used here was for an area greater than, but including, the one under study. The correlation between PRICE and PRICE INDEX was 0.624.



which represented the average level of income in the area. This was an 'amenity' variable intended to capture a demand side-effect (that is, people are more likely to pay a higher price to live in a wealthier, and presumably more educated, neighborhood).

The vector, X, included certain characteristics of the house that may have changed over time. First, AGE represented the age of the house, and the difference represented the time period between two sales. On the one hand, in general, the longer this period was, the more likely the house would experience a price increase. But that also meant that the house was older, and would dissuade some prospective buyers. The expected sign was thus ambiguous.

We were also able to obtain significant information on renovations that have affected houses. The RENOVATIONS variable represented the cumulative sum of money spent for renovations between two sales. These were renovations for which the owners had to apply for permits at City Hall. TYPICAL EXTERNAL referred to the number of usual external renovations that took place between two sales. By typical external renovation, we meant things like replacing the roof, or the doors. MAJOR EXTERNAL captured the number of major external renovations, such as the addition of a room or a garage, or a change in the siding (e.g., from aluminum to brick). MAJOR INSIDE represented the number of large-scale inside renovations, such as the bathroom or kitchen, while INGROUND POOL referred to the installation of this item. Note that for the last four variables, we had the information both in terms of the number of permits that were requested and in terms of the value (cost) of these renovations. Finally, the INFRACTIONS variable represented the number of infractions of the municipal building code detected by inspectors. These infractions had to be corrected in order for a house to comply with the building code, thus improving its quality; so, the expected sign of the coefficient of this variable was positive.

Laval's noise barrier is 2.3 kilometers (less than 1.5 miles) long. According to a study by an audiology expert (Ouimet, 1992), the noise barrier was a welcome impact on the noise level in the immediate neighborhood (reducing it from 76 to 62.3 dBa, on average). However, that impact was felt only within an area that was no farther than 300 meters (around 1,000 feet) from the wall. Therefore, the surface relevant to our study was quite long and narrow, and this was a residential sector bordered by a park and an industrial zone. For our RSA, we needed information on houses that sold at least twice during a certain period – before and after the construction of the wall.

In line with previous literature (Mendelsohn, et al., 1992; Gatzlaff and Smith, 1993; Hallstrom and Smith, 2005), we considered a period of 20 years for

our study: 10 years before, and 10 years after the construction of the barrier. Overall, we studied ALL 134 properties in the relevant area that were sold at least twice from 1980–2000. Actually, each house was sold 2.8 times on average, giving us 374 transactions and 187 observations (pairs of transactions) with which to work. Table 3 reports the number of transactions that took place before, during, and after the construction of the wall. We obtained the main information on house prices, transaction dates, and renovations from the Laval City Hall and Court House, data on the local housing market from the Canada Mortgage and Housing Corporation and a real estate company, and data on income from Statistics Canada.

A concern with RSA is that one requires a sample of houses that have been sold more often than average, possibly introducing a bias to the selection of the sample (see, for instance, Gatzlaff and Haurin, 1997).<sup>5</sup> On that score, we can present certain evidence that our sample does not suffer from this problem. First, our 134 houses accounted for 25% of the 549 houses in the area we defined. Second, Table 3 presents seven major characteristics of the houses in our sample and in the vicinity: 1) types of houses; 2) number of floors; 3) age; 4) number of lodging units; 5) municipal evaluation; 6) number of transactions; and 7) distance from the barrier. Again, apart from the number of transactions, which was obviously larger in our sample, we saw considerable similarities between our sample and the other houses in our area of study. Third, Figure 1 shows the evolution of the number of transactions over time in our sample and in the area of study, and the trends were remarkably similar. Altogether, we considered that our sample was fairly representative of the neighborhood.

Furthermore, we should note that the INCOME variable was not necessarily exogenous. For instance, an increase in property values could draw people with higher incomes to the area. The same line of reasoning could also apply to the PRICE INDEX variable. In order to clarify this issue, we performed a Hausman Test, reported in the Appendix, which did not reject the hypothesis of exogeneity of these two variables.

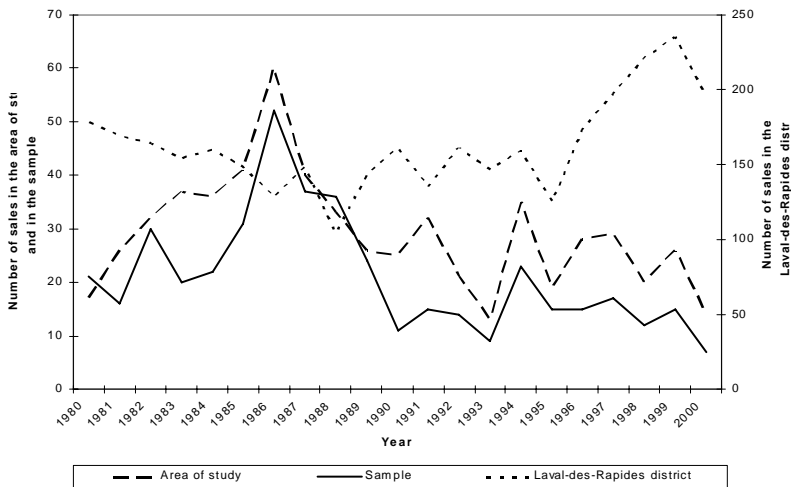
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<sup>5</sup> Actually, it would be possible to formally test whether our sample was biased, but this would require data on houses that had not been sold. It was impossible for us to obtain such information. Clapp, et al. (1991), Clapp and Giaccotto (1992), and Case, et al. (1997) showed in their samples that houses sold multiple times are not significantly different from houses sold twice. However, the results of Case, et al. (1991) and Gatzlaff and Haurin (1997) were more ambiguous. Furthermore, as shown by Gatzlaff and Ling (1994), Dombrow, et al. (1995), and Goodman and Thibodeau (1998), the use of an augmented repeated-sales model and controlling for heteroskedasticity with a large enough sample is another way of dealing with this issue.

**Table 3: Characteristics of the houses**

	Area of study	Sample
<b>Number of houses</b>	549	134
<b>Type of houses</b>		
Single family	71.6%	62.0%
Duplex	14.4%	15.3%
Triplex	7.6%	10.9%
Quadruplex	3.7%	7.3%
Multiplex	2.8%	4.4%
<b>Number of floors</b>		
Average	1	1
Minimum	1	1
Maximum	3	3
<b>Year of construction</b>		
Average	1958	1958
Minimum	1847	1847
Maximum	1997	1988
<b>Number of lodging units</b>		
Average	2	2
Minimum	1	1
Maximum	8	8
<b>Municipal valuation</b>		
Average	\$108,900	\$114,564
Minimum	\$9,400	\$50,400
Maximum	\$398,000	\$274,200
<b>Number of transactions</b>	610	442
Average	1.1	2.8
0 sale	41.5%	N/A
1 sale	31.8%	N/A
2 sales	15.4%	55.5%
3 sales	7.6%	24.8%
4 sales	3.1%	10.9%
5 sales	1.6%	6.6%
Pre-barrier	348	289
During barrier construction	57	26
Post-barrier	205	127
<b>Distance from the wall</b>		
Average	140m	135m
Minimum	5m	
Maximum	315m	
Number of houses adjacent to the wall	67	21
<b>Noise Level (Ouimet, 1992)</b>		
Pre-barrier	76.0 dB	N/A
Post-barrier	62.3 dB	N/A

**Figure 1 Evaluation of Transactions**



## Empirical results

Table 4 presents the empirical results for seven specifications of Equation (1). The first contains only the variables encountered in a typical RSA: the variables capturing the presence of the wall and the evolution of the real estate market. This specification allows us to evaluate how our “augmented” RSA performed, compared to the typical RSA.<sup>6</sup> Specification 2 used the value of renovations to capture the extent of the renovations performed between two sales, while Specification 3 used the quantity of these renovations. In Specification 4, we do not include the ‘economic and socio-demographic variables’ to test if they were jointly significant, and in Specification 5, we do not include the variables related to the characteristics of the houses. In both cases, with an F-test, we could not reject the hypothesis that stated that these two groups of variables were jointly significant. In Specifications 6 and 7, we introduced the DISTANCE2 variable; in 6 we measured renovations using the value of the renovations, and in 7 we measured renovations by the quantity. We performed tests to detect potential serial correlation, and did not reject the hypothesis of the

<sup>6</sup> However, we were not able to conduct a complete hedonic regression for comparison purposes. In order to run such a regression, one needs data for different characteristics of the house, such as the number of square feet, the number of rooms, the area of the land, etc. Unfortunately, we did not have access to this information. However, we ran a simple hedonic regression with the variables at our disposal, in which our central result, the coefficient of the BARRIER variable, was still negative, but less significant. The results are available upon request.

absence of a first-order serial correlation.<sup>7</sup> Furthermore, we carried out the estimates using the ordinary least-squares method, adjusted using White's (1980) heteroskedastic-consistent covariance matrix to correct the estimates for unknown forms of heteroskedasticity.

First, we could see from Specification 1 that when we used a standard RSA approach, the adjusted R<sup>2</sup> was considerably lower than when we used other specifications, so the "augmented" RSA version was preferable. This was confirmed with our F-test in Specifications 4 and 5. Furthermore, the other specifications (especially 2, 3, 6 and 7), which differed in terms of the variables used to capture the extent of the renovations performed between two sales, performed equally well and gave very similar results. The adjusted R<sup>2</sup> was slightly higher when we used the value of renovations.

Concerning the variables related to the noise barrier (vector *Z*), we first saw that the coefficient of BARRIER was very stable, negative, and significant in all specifications, indicating a value drop of about 11% following the introduction of the wall. However, the coefficient of the CONSTRUCTION variable was also very stable, positive, and significant, indicating a rise in value of about 5% during the construction of the wall. The positive coefficient of CONSTRUCTION suggested that buyers anticipated an improvement in the situation following the erection of a noise barrier, but the negative coefficient of BARRIER suggested that their expectations were not fulfilled and the negative aesthetic impact was greater than anticipated.

When we consider the net impact of these two variables, we can conclude that there was a decrease of around 6% in the price of adjacent houses in the short run, and 11% in the long run. This is in line with Ouimet's (1994) study, which reported that more people in the area thought that there would be a fall in the value of their houses following the construction of the barrier (29.5%) than those who believed the opposite (26.5%).<sup>8</sup> Our results contradict the rest of the literature, although we expressed doubts about the quality of previous studies. As mentioned above, it seems clear in the territory affected by the wall, and in a recent survey published by the U.S. Department of Transportation (2006b), that the negative effects of noise barriers are not negligible. Note that the coefficient of BARRIER is still very stable, negative, and significant when we remove the CONSTRUCTION variable.

The DISTANCE variable, capturing the distance from the wall, and the

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<sup>7</sup> Actually, The Durbin-Watson statistic was 1.241 and the Box-Pierce statistic was 11.849. In both cases, this was not significant.

<sup>8</sup> The rest of the people surveyed thought that the prices of their houses were not affected by the wall.

DISTANCE variable<sup>2</sup> were never significant, suggesting that all the houses were affected similarly by the construction of the wall. This could stem from the fact that houses located farther away benefit from a lower reduction in the noise level, but they suffer less from the visual impact. Omitting the DISTANCE variable had little impact on the results.<sup>9</sup>

**Table 4: Empirical results (t statistics)**

	1	2	3
	Basic RSA	Value	Qty
<b>R<sup>2</sup> adjusted</b>	0.4693	0.5434	0.5378
<b>Variables capturing the existence of the wall</b>			
CONSTANT	0.899E-03 (0.083)	0.005 (0.341)	-0.003 (-0.177)
BARRIER	-0.113 (-8.884)***	-0.105 (-5.394)***	-0.111 (-5.700)***
CONSTRUCTION		0.053 (2.496)**	0.051 (2.418)**
DISTANCE (IN METERS)		3.554E-05 (0.567)	9.135E-05 (1.467)
DISTANCE SQR			
<b>Economic and socio-demographic variables</b>			
PRICE INDEX	0.780E-02 (6.43)***	0.007 (10.991)***	0.007 (11.663)***
INCOME		2.926E-06 (3.721)***	2.647E-06 (3.329)***
<b>Changing characteristics of the houses</b>			
AGE		-0.008 (-2.850)**	-0.008 (-3.037)***
RENOVATIONS		-1.660E-05 (-1.337)	
TYPICAL EXTERNAL		2.059E-05 (1.512)	0.066 (3.016)***
MAJOR EXTERNAL		1.584E-05 (1.268)	0.012 (0.669)
MAJOR INSIDE		3.464E-05 (2.665)**	0.104 (3.152)***
INGROUND POOL		1.463E-05 (1.006)	-0.022 (-0.265)
INFRACTION		0.088 (3.155)***	0.006 (0.176)

<sup>9</sup> We also introduced an interaction term between BARRIER and DISTANCE that was never significant.

**Table 4: Empirical results (Continued)**

	4	5	6	7
	Value	Value	Value	Qty
<b>R<sup>2</sup> adjusted</b>	0.2355	0.4922	0.5423	0.5367
<b>Variables capturing the existence of the wall</b>				
CONSTANT	0.055 (2.968)**	-0.008 (-0.517)	0.008 (0.480)	0.002 (0.096)
BARRIER	-0.148 (-5.945)***	-0.138 (-8.668)***	-0.104 (-5.366)***	-0.110 (-5.665)***
CONSTRUCTION	0.165 (6.538)***	0.077 (3.905)***	0.052 (2.475)**	0.051 (2.268)**
DISTANCE (IN METERS)	-1.210E-05 (-0.150)	8.160E-05 (1.263)	-4.860E-05 (-0.198)	-1.280E-05 (-0.052)
DISTANCE SQR			2.863E-07 (0.354)	3.530E-07 (0.434)
<b>Economic and socio-demographic variables</b>				
PRICE INDEX		0.007 (10.734)** *	0.007 (10.959)** *	0.007 (11.625)** *
INCOME		2.075E-06 (2.707)**	2.930E-06 (3.721)***	2.652E-06 (3.321)***
<b>Changing characteristics of the houses</b>				
AGE	0.021 (8.098)***		-0.008 (-2.855)**	-0.008 (-3.045)***
RENOVATIONS	-2.970E-05 (-1.865)*		-1.650E-05 (-1.333)	
TYPICAL EXTERNAL	2.082E-05 (1.183)		2.051E-05 (1.504)	0.066 (2.974)**
MAJOR EXTERNAL	2.902E-05 (1.803)*		1.582E-05 (1.265)	0.012 (0.679)
MAJOR INSIDE	6.225E-05 (3.740)***		3.454E-05 (2.654)**	0.103 (3.133)***
INGROUND POOL	3.365E-05 (1.794)*		1.468E-05 (1.008)	-0.021 (-0.251)
INFRACTION	0.083 (2.316)*		0.089 (3.170)***	0.008 (0.220)

With respect to economic and socio-demographic factors (vector Y), we first found, not surprisingly, that the price difference between sales was strongly related to the evolution of the housing market in the neighborhood (PRICE INDEX), with an elasticity of 0.6. As expected, the INCOME level in the area also had a positive and significant impact on the price of houses (elasticity of 0.01).

Concerning the vector of houses' characteristics (X), the coefficients of certain variables were consistently significant across specifications. First, the AGE of a house was negatively associated with its price, suggesting that older houses are less attractive for households, maybe because of the cost of potential renovations. Second, the coefficients of the variables capturing

TYPICAL EXTERNAL renovations (the number of permits) and MAJOR INSIDE renovations (both the number of permits and the value of the renovations) were, as expected, positive and significant. Finally, the coefficient of the INFRACTIONS variable, capturing the number of infractions of the municipal building code, detected at the time of a sale, was positive and significant in the specifications in which we employed the value of renovations. This was expected, since these infractions led to further renovations before a house could be sold.

## Conclusion

In a society where people seek a better quality of life (less noise, less pollution, more safety, etc.), and where public authorities are sensitive to these requests and invest more resources to increase public welfare, we studied the impact of a particular measure aimed at improving public satisfaction: noise barriers. This paper is the first study on the impact of noise barriers on the price of adjacent houses based on RSA, which is arguably the best methodology for addressing this question. We focused on the neighborhood of Laval, a suburb of Montreal, where we were able to obtain information on 134 houses that were sold at least twice from 1980–2000. In addition, we were able to obtain data not only on the real estate market in the area for the same period, as in most RSAs, but also on the demographic composition of the area and major renovations carried out on these houses. We concluded that the noise barrier induced a decrease of 6% in house prices in our sample in the short run, and 11% in the long run. It would be useful to conduct similar studies in other areas to confirm the robustness of our results.

## Appendix: Hausman Test

Variables <sup>1</sup>	t-test	Hypothesis of exogeneity
	INCOME	0.627E-09
PRICE INDEX	0.175E-08	Not rejected

<sup>1</sup>The instrument used for the test is lagged variables.

\*Significant at 10%



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