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Living on a Noisy and Dusty Street: Implications for Environmental Evaluation*

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Résumé / Abstract

Cette étude propose trois contributions à la littérature s'intéressant à la méthode des prix hédoniques : i) le « contexte expérimental » est différent des études antérieures puisqu'il utilise un échantillon de transactions sur des propriétés résidentielles d'un même quartier, certaines localisées sur une rue « poussiéreuse et bruyante » et d'autres sur des rues « calmes et propres »; ii) ce contexte expérimental permet pour la première fois de combiner deux approches (la méthode des prix hédoniques et l'analyse des ventes répétées); et iii) contrairement aux études précédentes qui ne s'intéressaient qu'à un aspect environnemental, nous considérons l'impact de deux aspects environnementaux, le bruit et la qualité de l'air; ces deux aspects ayant été l'objet de mesures spécifiques pour cette étude. Nos résultats montrent qu'aucun des deux aspects de la qualité de l'environnement n'a d'effet sur le prix des propriétés résidentielles.

This paper contributes to the literature on the hedonic pricing method in three different ways: i) the "experimental context" is new and typical of many urban settings, i.e. comparison between the price of houses located on a "noisy and dusty" street and that of houses located on a "quiet and clean" street in the same neighborhood; ii) this experimental context allows us, in a sense, to combine for the first time two popular valuation methods (standard hedonic pricing and repeat-sale analysis); and iii) in contrast with previous studies that focused on one aspect of environmental quality, we investigate the impact of two environmental attributes on houses' price, namely noise and air pollution (dust), which have been measured specifically for this study. Our results show that neither of these environmental attributes has an impact on the houses' price.

Mots Clés : Marché immobilier, prix hédoniques, environnement, évaluation

Keywords : Housing market, Hedonic pricing, Environment, Environmental evaluation

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1. Introduction

Evaluating the benefits of improved environmental quality or the costs of environmental degradation is a difficult task because of the "non-market" nature of environmental goods. However, for sound public decision-making, it remains essential to account for these costs or benefits in the design of policies or projects. For this evaluation purpose, economists have set three principal methods designed to elicit what people are willing to pay for environmental quality: 1) the travel cost approach in which environmental attributes are valued through the expenditures people are willing to pay to participate in outdoor activities ; 2) contingent valuation in which people are asked directly, through a questionnaire, what they are willing to pay for environmental amenities ; and 3) the hedonic pricing method in which the value for the environment is deducted from price differentials, for instance, of houses with different environmental attributes. Each method has its pros and cons and is applicable in specific circumstances.

Typically, in the hedonic pricing method, regressions are run in which houses' price is related to a vector of characteristics (physical characteristics of the house, market conditions, neighborhood), including a variable capturing a certain environmental attribute. So far, this method has been used to evaluate air pollution (Nourse, 1967, Brookshire et al., 1982, Graves et al., 1988), proximity of dump sites (Kohlhase, 1988, Bleich et al., 1991), airport noise (O'Byrne et al., 1985), proximity of a train station (Gatzlaff and Smith, 1993, Forrest et al., 1996), and traffic noise (Hughes and Sirmans, 1992).

Some authors (e.g., Palmquist, 1982, Kohlhase, 1988, 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 houses' price and the effect of unobserved characteristics (eg., criminality in the neighborhood). These authors have suggested a variant of the standard hedonic pricing method, the repeat-sale analysis (RSA). With this technique, researchers examine the difference in the price of the same house sold before and after an event that had a considerable impact on the environment (e.g., the nuclear accident at Three Mile Island). Assuming that the characteristics (observed and unobserved) of the house have not been modified, they can attribute the price difference to the change in the environmental quality[1] .

This paper contributes to the literature on the hedonic pricing method in three different ways. First, the « experimental context » in which

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[1] The constant characteristic assumption may not be realistic if the time period between two sales is relatively long.

we situate our research is new. Indeed, we examine the price differential between houses located on a « noisy and dusty » street and houses located on a « quiet and clean » street in the same neighborhood in Montreal[2]. This urban context is quite typical in contrast with the rest of the literature that has examined more « spectacular » environmental features (airport noise, toxic dumping sites, nuclear accident, etc.). As such, the exercise could be useful for policy makers who need to evaluate policies promoting public transportation, modifying traffic rules or changing industrial zoning.

Second, this experimental context allows us, in a sense, to combine for the first time the two valuation methods described above (standard hedonic pricing and RSA), since selecting houses in the same area implicitly controls for a large part of the unobserved heterogeneity due to the neighborhood specific attributes. Third, in contrast with previous studies that focused on one aspect of environmental quality, we investigate the impact of two environmental attributes on houses' price, namely noise and air pollution (dust), which have been measured specifically for this study. In doing so, we explore the ability of the market to disentangle between different environmental characteristics.

The rest of the paper is organized as follows. Section 2 presents the empirical model, while Section 3 describes the data in more details. Section 4 presents and discusses the empirical results showing that neither of the environmental attributes under study has an impact on houses' price. Section 5 provides some concluding remarks.

2. Empirical model

Standard hedonic pricing theory stipulates that asset prices reflect the expected future benefits of the characteristics of an asset. Empirical house pricing models divide these characteristics into four broad categories: physical characteristics of the house, external (neighborhood) characteristics, market conditions and environmental attributes.

The goal of this paper is to determine if the housing market takes into account the effects of noise and air pollution (dust) within the same neighborhood. Since the effects of noise and dust are not priced independently, the hedonic pricing technique developed by Rosen (1974) is used to evaluate the implicit prices of these environmental attributes. The standard hedonic model to be estimated is as follows:

$$\text{Price}_{it} = f(\text{Ph}_i, \text{Ex}_i, \text{M}_t, \text{Ea}_i; \beta, u_{it}), \qquad (1)$$

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2 Hughes and Sirmans (1992) have examined price differentials attributable to traffic, using houses in different neighborhoods.

where $Price_{it}$ is the selling price of house i at period t, Ph_i is a vector of physical attributes for house i, Ex_i is a vector of external characteristics, M_t includes different measures of market conditions at the time the transaction was made and Ea_i includes variables measuring the environmental attributes to which house i is exposed. β' is a vector of parameters and u_{it} is a disturbance with $E(u_{it})=0$. The specific variables included in *Ph*, *Ex*, *M*, and *Ea* are described in details below.

Of particular importance is the sign and magnitude of the coefficients associated to the environmental attribute variables. If the market is in equilibrium, these coefficients summarize the marginal effect of the environmental attributes. We expect that, everything else being equal, the houses that are more exposed to noise and/or dust will have a lower value.

There is no guidance from theory on the adequate functional form of equation (1). Several researchers have based their estimation on a semilog functional form (see, for instance, Forrest et al., 1996). Box-Cox transformations have also been used, but no conclusive results arise from that stream of research (Graves et al., 1988).

Our approach is different from the aforementioned studies. Instead of considering the chosen functional form as the true form of equation (1), we see it as an approximation around an arbitrary point. Hence, to approximate equation (1), we use the following Taylor series expansion:

$$ln(\mathrm{Price_{it}}) = \beta_0 + \beta_1' X_{1i} + \beta_2' X_{2i} + \beta_3' X_{3it} + 1/2\,\beta_{22} X_{2i}^2 + \beta_{12} X_{1i} X_{2i} + u_{it}, \qquad (2)$$

where X_{1i} is a vector which includes all the continuous variables except the environmental attributes, X_{2i} is the environmental attribute (dust or noise) and X_{3it} is the vector containing all the binary variables. All continuous variables are divided by their sample mean, the point around which the function is approximated. Using (2), several econometric models are considered : a semilog model where the continuous variables are untransformed, a quasi-translog model where we used the log of the continuous variables and an hybrid Box-Cox/translog model where a Box-Cox transformation is applied to the environmental variable, while the other continuous variables are used in log form.

In order to limit the number of estimated parameters and since the focus of the paper is on environmental attributes, we only expand the Taylor series to second-order terms involving environmental variables. A full second-order expansion would imply the estimation of 15 additional parameters. All models have been estimated using OLS and White's (1980) heteroscedastic-consistent standard errors of the parameters.

The second-order cross product term $X_{1i}\,X_{2i}$ can be interpreted as an interaction effect as in Rasmussen and Zuehlke (1990). Hence, it is possible that the effect of the environmental variables on the price of the house is related to its physical or external characteristics. For instance, owners of larger lots may value more outdoor life and, therefore, may be more sensitive to the environmental attributes of their property.

3. Data

The experimental context is one in which we compare the price of houses on a dusty and noisy street with the price of houses on quiet and clean streets in the same neighborhood. The noisy street is a segment of a main boulevard in Montreal, Canada (Boulevard St-Michel). This boulevard has six lanes and is used for bus lines. Interestingly, we were able to delimit a segment on this boulevard where we only find residential properties. This setting is rather unique in Montreal since most wide streets are mainly commercial. The quiet streets are the second and third streets to the west and to the east of the noisy street. These are one-lane one-way streets on which buses do not circulate. Since we want our experiment to implicitly control for the characteristics of the neighborhood, we chose an area which is altogether less than one square mile, and which is fairly homogeneous in terms of access to recreational, commercial and working areas.

We were able to collect data on transactions for 171 different houses in this area within the period 1987-1991. Forty-eight of these transactions relate to houses on the noisy street, while the rest are on the quiet streets. Almost all of these transactions concern duplexes and triplexes. Table 1 provides descriptive statistics related to all the variables used in this analysis.

Central to our analysis are the measures of the **environmental attributes** (*Ea*), noise and dust, which were gathered specifically for this research. First, the DUST measure is defined as the concentration of suspended particles in the ambient air. Measures were taken at six different representative places in the area and on two different weekdays, as reported in Table 2. Houses were divided into six groups in function of their distance to the measurement points, and were assigned one of the six dust measures. Second, NOISE is measured as the average number of decibels recorded in one day. This measure was taken at fourteen different places in the area on two different weekdays (see Table 2).

Regarding the other variables used in the analysis, let us first note that the **dependent variable** (*Price*) is the price of the house in current Canadian dollars. Among the **physical characteristics** (*Ph*) of the house, we have the number of APARTMENTS (two or three since we are dealing with duplexes and triplexes), the total number of ROOMS in the house, the total SURFACE of the living area in the house, the total surface of the LAND, the AGE of the house, dummy variables to capture the nature of the

PARKING area (see the exact definition in Table 1), and one variable to capture whether or not the BASEMENT is usable as a living area. The expected sign of these variables is as in the rest of the literature and should be fairly self-explanatory.

Closer examination of the area where data was collected led us to conclude that, in spite of the fact that all houses are in the same neighborhood, certain specific **external** elements of this neighborhood ought to be taken into consideration. First, we define a variable to capture the fact that a house could be among the first three ones next to a street corner, which can affect negatively its value. Second, we define a variable, PARK, which is equal to one if the house is two blocks away or less from the unique park in the area. Third, a binary variable (SUBWAY) is equal to one if the house is two blocks away or less from the subway station which is just outside the area under scrutiny. These last two variables should have a positive effect on houses' price. Finally, as in Hughes and Sirman (1992), the **market** conditions are captured by dummy variables for each year during the period under study.

4. Empirical results

Table 3 presents the empirical results with two different functional forms: i) semilog and ii) quasi-translog. We also estimated the price equation using a Box-Cox transformation of the environmental attribute variables in the quasi-translog case . The results, available upon request, were imperceptibly different from those obtained with the logarithmic transformation of the environmental variables.

Results are fairly robust across functional forms and the R^2 , which are roughly the same for all models, are quite high for this type of data. However, more coefficients are significant in the quasi-translog estimation, namely AGE, LAND, SURFACE and PARKING2. Since these variables are believed to be key determinants of the value of a property, our results illustrate the dominance of the quasi-translog model over the semilog[3]. Therefore, only the results obtained with the quasi-translog model are discussed in details below. Furthermore, given the strong correlation between the two environmental attributes (0.99), we present two specifications for each functional form in which each attribute is entered separately (we will come back to this point later on).

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3 Some attempts have also been made with a completely linear model and the results were worse than those obtained with the semilog model in terms of key parameter statistical significance.

Regarding the **physical characteristics** of the house, our results show that the surface of the house, the surface of the land, the existence of an indoor parking and the fact that the basement is usable as a living area all have a positive and statistically significant effect on the price of the house, as expected, while the age of the house has a negative and significant effect. The number of apartments and the number of rooms are not significant determinants of the price; their influence may have been captured by the SURFACE variable.

Among the **external** variables, the existence of a PARK near the house has a positve influence on the price, while the proximity of a subway station and of the corner of a street seems less influential. Furthermore, the year dummies, included to capture **market conditions**, all have a positive and significant coefficient, which is consistent with the boom observed in the Montreal housing market during that period. Over these years, prices were growing steadily, as it is reflected in the increase of the coefficients associated to YEAR88, YEAR89 and YEAR90. Moreover, the relative decline of the coefficient associated to YEAR91 corresponds to the end of that booming period.

Turning to the **environmental attributes**, as mentioned earlier, the very strong correlation between DUST and NOISE did not allow us to obtain precise estimates when both were included in the specification; thus we decided to enter them separately. This indicates that, even if these two kinds of attributes may have a fairly different impact on health and comfort, the market is probably unable to value them separately or, at least, the type of analysis we offer cannot disentangle between the two.

When the environmental attributes are considered individually, they turn out to have no impact on houses' price (their coefficient even has an unexpected positive sign in the semilog specification). The interaction terms between attributes and physical characteristics are also non-significant. This result requires careful consideration. Essentially, two explanations related with each other can be invoked to understand this result: 1) these environmental attributes truly have no or very little value, or 2) they have some value but it cannot be detected with the methodology and data we use.

Regarding the first explanation, a number of arguments can be provided. First, maybe we are facing a selection problem: people decide to live either downtown or in the suburb and once they have decided to live downtown, they do not really care about the street on which they live. Second, specific characteristics of our experimental context (duplexes and triplexes) may explain why environmental attributes have very little value: i) in line with the preceding argument, people who choose to live downtown probably have a lower value for pure air (for instance, they are less likely to have kids) ; ii) the houses in our sample are accessible to people with relatively low income (the average value is relatively low at $130,910 and owners have rental revenues), and it has been shown elsewhere that environmental quality is a normal good (e.g., Grossman and Krueger, 1995); and iii) owners of multi-apartment houses sometimes do not live in these houses so that their value for environmental attributes could be small.

Concerning the second explanation, different points come to mind. First, there may be some unobserved benefits of living on a main street (like better access to public transportation, quicker snow removal during winter, etc.) that could compensate for the inconvenience of noise and dust. We could not account for such benefits. Second, maybe our environmental measures are not perfectly accurate so that their effects cannot be precisely estimated. However, we are comforted by the fact that our measures are similar to those used in other studies and by the fact that they were collected specifically for this study by professionals who designed their measuring protocol given the purpose of our research. Lastly, it is noteworthy that, in contrast with many existing studies, we are not dealing with spectacular environmental attributes (like existence of an airport, air pollution in Los Angeles, toxic dumping site etc.) so that people may have a small value for them that cannot be detected by regression analysis.

5. Conclusion

This paper has contributed to the literature on hedonic pricing method in three different ways: i) the « experimental context » was new and typical of many urban settings, i.e. comparison between the price of houses located on a « noisy and dusty » street and that of houses located on a « quiet and clean » street in the same neighborhood; ii) this experimental context allowed us, in a sense, to combine for the first time two popular valuation methods (standard hedonic pricing and repeat-sale analysis); and iii) in contrast with previous studies that focused on one aspect of environmental quality, we investigated the impact of two environmental attributes on houses' price, noise and air pollution (dust), which have been measured specifically for this study.

Our results have shown that neither of these environmental attributes has an impact on houses' price. Even if these findings are somewhat disappointing, our exercise was still worthwhile given the two main reasons that may explain our results. First, in this urban context, the environmental attributes at stake may truly have very small or no value, in which case our study indicates that these attributes should have little weight in public decision-making. Second, these attributes may have some value but it could not be detected with the data and methodology we used, in which case our study suggests that an alternative valuation method (like contingent valuation) could be useful in this context. Comparison between contingent valuation results and hedonic pricing results in a similar experimental setting could be a fruitful exercise to add on our research agenda.

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Table 1. Descriptive Statistics of the Variables Used in the Analysis

Name	Definition	Mean	Variance
PRICE	Price in dollars	130 913,40	0.12414E+10
Physical Characteristics (Ph)			
AGE	Age of the house	52,357	204,58
LAND	Surface of the land in square feet	2 589,60	1 233 200,00
SURFACE	Surface of the house's living area in square feet	2 132,80	213 490,00
ROOMS	Total number of rooms in the house	12,263	8,4539
APARTMENTS	Binary variable = 1 if the house is a triplex, 0 otherwise	0,6667	0,2235
PARKING1	Binary variable = 1 if the house has an outdoor parking, 0 otherwise	0,16374	0,13774
PARKING2	Binary variable = 1 if the house has an indoor parking, 0 otherwise	0,33333	0,22353
BASEMENT	Binary variable = 1 if basement is usable as a living area, 0 otherwise	0,39766	0,24094

Table 1. Descriptive Statistics of the Variables Used in the Analysis (cont'd)

External Characteristics (Ex)			
CORNER	Binary variable = 1 if the house is one of the three first houses next to a corner, 0 otherwise	0,42690	0,24610
PARK	Binary variable = 1 if the house is two blocks away or less from the park, 0 otherwise	0,093567	0,085311
SUBWAY	Binary variable = 1 if the house is two blocks away or less from the subway, 0 otherwise	0,052632	0,050155
Market Conditions (M)			
YEAR88	Binary variable = 1 for transaction in 1988, 0 otherwise	0,29825	0,21053
YEAR89	Binary variable = 1 for transaction in 1989, 0 otherwise	0,16374	0,13774
YEAR90	Binary variable = 1 for transaction in 1990, 0 otherwise	0,040936	0,039491
YEAR91	Binary variable = 1 for transaction in 1991, 0 otherwise	0,099415	0,090058
Environmental Attributes (Ea)			
DUST	Concentration of suspended particles in ambient air	0,05655	0,00046
NOISE	Average number of decibels registered during 24 hours	55,725	96,489

Environmental Attributes

Table 2a. Measure of Dust

Position of the reading	Address	Date	Conc.[1] (mg / Nm^3)
CENTRAL	5796, St-Michel	18-19/11/93	0,108
NORTH-WEST	6380, 9th Avenue	18-19/11/93	0,046
NORTH-EAST	6404, 13th Avenue	18-19/11/93	0,048
CENTRAL	5796, St-Michel	29-30/11/93	0,078
SOUTH-WEST	5524, 8th Avenue	29-30/11/93	0,040
SOUTH-EAST	5488, Lafond	29-30/11/93	0,042

[1] Conc: concentration of suspended particles in ambient air measured in milligrams/cubic meters (mg/Nm^3).

Table 2b. Measure of Noise

Position of the reading	Leq (24 hours) dBA[2]
A1) 6825, St-Michel	70,5
A2) St-Zotique and St-Michel	69,0
A3) 6745, 8th Avenue	54,0
A4) 6736, 9th Avenue	53,0
A5) 6820, 13th Avenue	50,0
B1) De l'Ukraine and St-Michel	68,0
B2) 6235, 9th Avenue	53,0
B3) 6300, 8th Avenue	49,0
B4) 6322, 12th Avenue	58,0
B5) 6382, 13th Avenue	50,0
C1) 5658, St-Michel	72,0
C2) 3125, Dandurand	54,0
C3) 5685, 9th Avenue	49,0
C4) 5640, Lafond	48,0

[2] The decibel dBA is a proxy of noise intensity measured in Leq (24 hours), i.e. average sound magnitude during 24 hours. This is an average of observations taken on two different days.

Sources: *DUST* - *Sodexen, 1994; NOISE* - *Ministère des transports du Québec.*

Table 3. Parameter Estimates of the Hedonic Price Function[1]

Dependent Variable: ln(PRICE) **(t-ratios in parentheses)[2]**

Variable[3]	**Semilog Specifications**		**Quasi-translog Specifications**	
	DUST	**NOISE**	**DUST**	**NOISE**
INTERCEPT	10.6154*	10.3476*	11.6305*	11.6253*
	(21.973)	(3.912)	(210.842)	(145.961)
AGE	-0,0869	0,0795	-0.1576**	-0.1571**
	(-0.621)	(0.280)	(-2.237)	(-2.293)
LAND	0,1638	0,3347	0.1223*	0.1315*
	(1.058)	(1.328)	(2.598)	(3.098)
SURFACE	0.7920*	0,8780	0.7449*	0.7501*
	(2.600)	(1.613)	(6.575)	(6.476)
ROOMS	-0,0888	-0,0344	-0,1101	-0,1178
	(-0.361)	(-0.072)	(-1.290)	(-1.359)
APARTMENTS	0,0382	0,0358	0,0376	0,0360
	(1.038)	(1.004)	(0.975)	(0.963)
EA (Dust or Noise)	0,7222	0,8043	-0,0106	-0,0362
	(0.857)	(0.164)	(-0.156)	(-0.130)
(EA) * (EA)	-0,3744	-0,0558	-0,2553	-0,5177
	(-0.519)	(-0.013)	(-0.395)	(-0.115)
AGE * (EA)	-0,1274	-0,2991	-0,0738	-0,1960
	(-0.908)	(-1.029)	(-0.559)	(-0.726)
LAND * (EA)	-0,0726	-0,2299	-0,0569	-0,1923
	(-0.557)	(-0.923)	(-0.424)	(-0.752)

Table 3. Parameter Estimates of the Hedonic Price Function[1] (cont'd)

Dependent Variable: ln(PRICE) **(t-ratios in parentheses)[2]**

Variable[3]	Semilog Specifications		Quasi-translog Specifications	
	DUST	NOISE	DUST	NOISE
SURFACE * (EA)	-0,0897	-0,1780	-0,1158	-0,2109
	(-0.366)	(-0.362)	(-0.370)	(-0.341)
ROOMS * (EA)	-0,0098	-0,0664	0,0683	0,0888
	(-0.046)	(-0.147)	(0.242)	(0.155)
PARKING1	-0,0328	-0,0347	-0,0144	-0,0173
	(-0.689)	(-0.697)	(-0.318)	(-0.366)
PARKING2	0,0430	0,0404	0.0491***	0.0473***
	(1.539)	(1.450)	(1.752)	(1.683)
BASEMENT	0.0721**	0.0741**	0.0795**	0.0815**
	(2.178)	(2.297)	(2.140)	(2.275)
CORNER	-0,0162	-0,0166	-0,0149	-0,0155
	(-0.713)	(-0.730)	(-0.670)	(-0.696)
PARK	0,0980	0.1017**	0.0956**	0.0947**
	(2.546)**	(2.187)	(2.548)	(2.050)
SUBWAY	0,0658	0,0642	0,0596	0,0577
	(1.058)	(1.038)	(0.944)	(0.930)
YEAR88	0,1019	0.1005*	0.0982*	0.0977*
	(3.581)*	(3.562)	(3.484)	(3.487)
YEAR89	0,1568	0.1546*	0.1545*	0.1533*
	(4.953)*	(4.952)	(5.020)	(5.038)

Table 3. Parameter Estimates of the Hedonic Price Function[1] (cont'd)

Dependent Variable: ln(PRICE) **(t-ratios in parentheses)[2]**

Variable[3]	**Semilog Specifications**		**Quasi-translog Specifications**	
	DUST	**NOISE**	**DUST**	**NOISE**
YEAR90	0,2012	0.2015*	0.1906*	0.1904*
	(4.377)*	(4.355)	(3.952)	(3.938)
YEAR91	0,1306	0.1319*	0.1245*	0.1245*
	(3.383)*	(3.508)	(3.281)	(3.401)
R^2 (adjusted)	0,67	0,67	0,68	0,68

1- Specifications with a Box-Cox transformation on the DUST and NOISE variables have also been estimated. The results, not presented here but available upon request, are very similar to those obtained with the logarithmic specification.

2- Computed from Robust-White heteroscedastic-consistent standard errors.

3- All continuous variables are divided by their mean.

* Statistically significant at the 1% confidence level

** Statistically significant at the 5% confidence level

*** Statistically significant at the 10% confidence level

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