# Airport noise and residential property values : Evidence from Beijing

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**Abstract** Cities are used to develop in the vicinity of transport hubs : formerly near waterways and ports, then around railways and highways. More recently, globalization requires cities to contribute to the international flows of passengers, goods and information. Thus, air transportation industry plays a major role in the economic development of an urban area. In China, the number of civil airports increased significantly in recent years. Most airports are built in suburban areas because noise generated by airports is considered as a disamenity towards neighboring areas. Some scholars have already studied this phenomenon – particularly in North America and Europe. In China, although this issue receives wide media coverage, the question is still discussed in the academic circle. The paper is based on transaction data in residential areas close to Beijing Capital International Airport. By using econometric models and estimating them via the hedonic price method, we derive the impact of aircraft noise on the willingness to pay for residential properties. The results suggest that a 1 dB increase in noise exposure leads to a 1.05% to 1.28% depreciation of property values. This estimate is on the high side compared to other international NDI studies.

## 1 Introduction

Since China's economic reforms in 1978, the rapid economic growth and the opening of China to the outside world have come together with the important growth of air transportation industry. The soaring of the aviation activity has required tremendous efforts in increasing the number of airport infrastructures. In particular, many airports have been constructed and have dramatically changed China's air passenger transport network. The number of civil airports increased from 77 in 1980 [8] to 175 in 2010, and a total of 220 civil airports is expected by

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2020. Today, 61 percent of the Chinese population has an airport at less than 100 kilometers. In 2020, this proportion is expected to reach 82 percent of the country's population. To achieve this goal, the government has to build airports close to areas that are more populated, that is to say, into cities.

In practice, there are many reasons why most airports are built in suburban areas or near the city's edge. First, building an airport requires a large parcel of land, generally several dozens of square kilometers to accommodate runways, terminals, facilities and internal transportation. While considering the location for building an airport, governments give priority to areas located far from the city center because the concentration of people living and working is lower in these areas, so the need to relocate people is less important. Secondly, after the completion of the airport, noise pollution generated by airports is considered as a disamenity towards neighboring areas.

The paper focuses on the negative externality of Beijing Capital International Airport (BCIA). Because aircraft noise is a non-market environmental good, we use econometric models to derive the implicit price of noise based on information about the value of properties located in the vicinity of BCIA. Then, the hedonic price method is used to estimate the Noise Depreciation Index (NDI) that reflects the depreciation of properties values caused by airport noise exposure. BCIA is an interesting case since it is the world's second busiest airport (79 million passengers in 2011) and it is located within the urban fringe of the metropolitan area of Beijing, a relatively urbanized area. Knowing the implicit price of noise is useful in order to implement more appropriate policy measures (e.g. compensation for people who are subjected to airport noise exposure), and land-use planning regulations.

The remainder of the paper is divided as follows. Section 2 provides a summary of aircraft noise studies from the literature. Section 3 describes the data and the econometric model used in the study. Section 4 presents the regression results. Section 5 concludes the study.

## 2 Aircraft noise in the literature

Since the beginning of hedonic price studies in the late 1960's, research has been prolific on amenities and property values. The hedonic price method is based on the hypothesis that, in a competitive housing market, the selling price of a property depends on its characteristics. Other things remaining unchanged, a property located with a better location will have a higher selling price. On the other hand, there are some disamenities which can affect neighboring properties and lead to a lower selling price. Their impact on housing prices can be derived by examining the willingness to pay for a particular attribute (e.g. distance to this disamenity). An airport is a typical disamenity that can severely affect neighboring areas subjected to aircraft noise. The hedonic price function of a property can be expressed as :

$$\ln P = \alpha + \mu Z + \mu_N N + \varepsilon \quad (1)$$

where $Z$ is a vector containing all characteristics excepted noise level, $N$ is the noise level, $\alpha$, $\mu$ and $\mu_N$ are the associated parameter vectors, and $\varepsilon$ is the error term.

The hedonic price function only represents the locus of buyer and seller equilibrium points for each attribute, and parameter vectors reveal an estimate of the marginal willingness to pay for each particular attribute [5]. In particular, $\mu_N$ also represents the noise depreciation index (NDI), that reflects the willingness to pay for quiet (Equation 2). More precisely, the NDI represents the average house value decrease caused by a 1 decibel (dB) increase in airport noise exposure.

$$\mu_N = \frac{\partial \ln P}{\partial N} \quad (2)$$

More than 50 studies have focused on estimating NDI for many airports worldwide. Due to the large amount of aircraft noise studies, some scholars have collected NDI estimates in order to perform meta-analysis[2] of these estimates. Nelson (1980) [2] summarized 18 NDI estimates from 13 studies, and concluded that "the noise discount is commonly 0.5-0.6%, although a higher value may occur in some high-income areas". Schipper et al. [6] and Nelson (2004) [3] also performed their own meta-analysis. Table 1 presents a summary of their findings.

**Table 1.** Summary of NDI estimates meta-analysis

| Author | Year | Number of estimates | Conclusion |
|---|---|---|---|
| Nelson | 1980 | U.S. (13)<br>Canada (2)<br>U.K. (2)<br>Australia (1) | NDI ≈ 0.5%-0.6%<br>(higher in high-income areas) |

[2] A meta-analysis is a statistical analysis of research findings, which aims at comparing outcomes of studies that estimate a particular elasticity (in general). In our case, a meta-analysis is useful in understanding how "transferrable" these results are, and if these estimates are similar [6].

| | | | |
|---|---|---|---|
| Schipper et al. | 1998 | U.S. (21) | NDI = 0.9% (non-linear specification) |
| | | Canada (5) | NDI = 1.3% (linear specification) |
| | | U.K. (2) | |
| | | Australia (2) | |
| Nelson | 2004 | U.S. (26) | NDI ≈ 0.5%-0.6% (U.S.) |
| | | Canada (7) | NDI = 0.9% (Canada) |

These different NDI estimates indicate that housing prices do not react equally across countries. For example, Nelson (2004) argue that Canadian airports impact more surrounding properties that in the United States. This variation can be due to different airport scales or different urban spatial structure. However, the use of different noise metrics or different estimation procedure also account for a considerable part of the variation in these NDI estimates.

The question whether NDI and wealth are positively correlated is still discussed in the literature. While Schipper et al. (1998) constructed a "relative mean sample house price" variable and concluded that NDI estimates and wealth are positively correlated, Nelson (2004) questioned the construction of the this variable since dividing the mean sample house price by the average per capita income in the entire urban area (instead of the mean income of the sample property owners) is obviously a misspecification. He carried his own meta-analysis and found that property values had no statistically significant impact on NDI estimates. This suggests that people of different wealth are willing to pay the same amount to avoid aircraft noise. Using the "PPP adjusted GDP per capita" as an indicator of a country's wealth, Wadud [7] performed a meta-regression and concluded that the NDI tends to be higher in developed countries. He predicted an estimated NDI of 0.23% per dB in China.

There is only one study that does not use hedonic price method in the literature. By analyzing the results of contingent valuation surveys, Feitelson et al. [1] conducted a telephone survey in an geographic area near a major hub airport. They asked to home owners and renters about their willingness to pay (WTP) for a house in an area with no aircraft noise at all, and the same house with different levels of noise exposure. They concluded that the difference in valuation of these WTP are between 2.4% and 4.1% of house prices for home owners, and 0.9-1.5% of rents for renters.

## 3 Data and model

The study examines the housing market close to Beijing Capital International Airport, in Shunyi District. Located in the Northeast of the municipality of Beijing, it is considered as the inner suburb of Beijing. Second-hand housing transactions data from the Chinese “Woaiwojia” real estate agency were collected from several residential areas. We decide to consider only apartments that have been sold between June 2006 and January 2012 within a 5 kilometers radius of Beijing Capital International Airport, since this area is particularly exposed to aircraft noise. The study area is represented in blue in Figure 1.

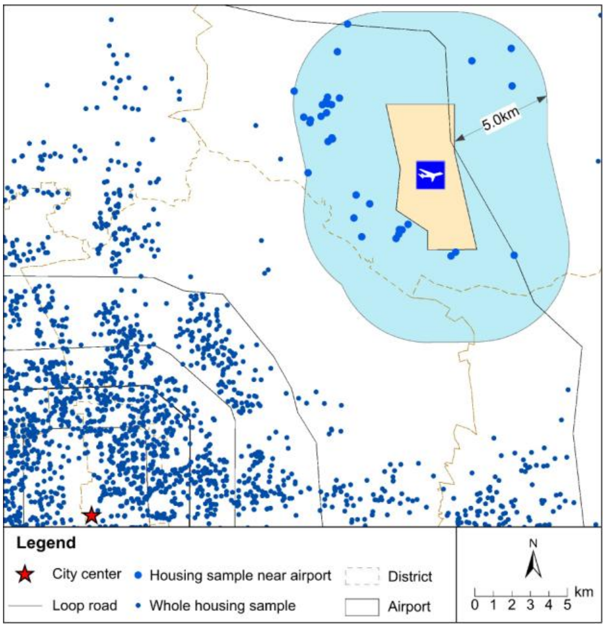


**Fig. 1.** Study area and distribution of sample properties

Data on property transactions include the sale price, the transaction date, structural house characteristics (e.g. surface area, building age, apartment floor) and spatial characteristics (e.g. distance to the airport) for 130 transactions. Table 2 contains the summary statistics of the variables used in the study.

**Table 2.** Summary statistics

| Variable | Description | Mean | Std. Dev. |
|---|---|---|---|
| price | Transaction price (x 10,000 RMB) | 123.98 | 97.9150 |
| area | Surface area (m²) | 94.795 | 65.1053 |
| floor | Apartment floor | 4.8231 | 3.4382 |
| n_ro | Number of rooms | 2.2769 | 1.5800 |

| | | | |
|---|---|---|---|
| n_ba | Number of bathrooms | 1.1615 | 0.4278 |
| n_li | Number of living rooms | 1.2769 | 0.5430 |
| years | Building age (years) | 7.9769 | 4.5808 |
| distance | Distance to the airport (km) | 3.1829 | 0.7977 |

We use a standard hedonic price function with log-linear specification (see Equation (1)) to estimate the effect of airport noise on the willingness to pay for properties. We add year dummy variables to control for the general upward trend of the Chinese housing market, and consider the year 2006 as the baseline for the sample. Since we do not have any information about aircraft noise exposure in these residential areas, we examine the impact on property value of getting closer to the airport. Then, examining different noise contour lines (e.g. Pope [4]) enables us to estimate the increase in noise exposure when the distance decreases by 1 kilometer. Noise contour lines are nearly ellipsoid-shaped lines with a major axis corresponding to the direction used by aircrafts for taking-off and landing, and a perpendicular minor axis. Getting closer to the airport by 1 km within the major axis direction generally lead to a noise exposure increased by 3 to 4 dB, while the same distance within the minor axis direction can increase noise exposure by 10 to 12 dB. In average, we suggest that a 1 km decrease in distance to the airport leads to an increase in noise exposure by approximately 7 to 8 dB.

## 4 Results

Regression results are presented in Table 3. Column (1) presents the regression results for the model that considers floor area as the only structural characteristic of properties. Column (2) estimates the model that includes all explanatory variables. We report t-statistics in parentheses under the coefficient estimates.

Results are quite consistent in both cases: the adjusted $R^2$ indicates that the explanatory variables account for 84% of the variation in properties prices, that is rather satisfying given the small number of explanatory variables. All the signs of the regression coefficients are as expected. People are more likely to pay a higher sale price for a property with a higher surface area, the negative coefficient associated with the square of the floor area indicates that the relation between the percentage increase in property value and the surface area is not linear, but quadratic. In other words, property values increase more and more slowly as surface area increases. The coefficient for the variable that indicates the apartment floor is not statistically significant. Within our sample, people are willing to pay the same amount to purchase an apartment at the first floor or at the tenth floor. People value more an apartment located in a building that has been constructed more recently.

Finally, we also perform a robustness test (not represented in the table) by replacing distance with its natural logarithm in the model. The coefficient associated to log(distance) is also positive and quite significant, suggesting that these results are relevant and reliable.

**Table 3.** Regression results (***, **, * = significant at 1%, 5%, 10% level)

| Variable | (1) | (2) |
|---|---|---|
| distance | 0.0840** | 0.0896** |
| | (2.37) | (2.38) |
| area | 0.0126*** | 0.0120*** |
| | (11.34) | (7.35) |
| area² | $-1.50*10^{-5}$*** | $-1.51*10^{-5}$*** |
| | (-5.70) | (-5.41) |
| floor | | -0.0020 |
| | | (-0.21) |
| n_ro | | 0.0402 |
| | | (1.05) |
| n_ba | | 0.0458 |
| | | (0.48) |
| n_li | | -0.0683 |
| | | (-0.90) |
| years | -0.0136** | -0.0142** |
| | (-2.24) | (-2.02) |
| Constant | 2.6473*** | 2.6068*** |
| | (12.65) | (10.67) |
| Fixed year effects | YES | YES |
| Observations | 130 | 130 |
| Adjusted $R^2$ | 0.84 | 0.84 |

Distance to the airport and property price are positively correlated, that means that a property closer to the airport will sell at a lower price. In Column (1), the coefficient associated with distance shows that if the distance between a property and the airport decreases by 1 kilometer, the value of this property *ceteris paribus* decreases by 8.4%. When we add all structural characteristics as explanatory variables in Column (2), the property value decreases by 8.96% for each kilometer. The two coefficients in both columns are similar, suggesting that the estimate is quite robust. Actually, without aircraft noise, airport is a positive amenity since an airport provides a high concentration of travel and employment opportunities. But in our regression results, the positive coefficient indicates that airport is a dis-amenity for residents who live close to it. This phenomenon is caused by noise pollution generated by aircraft and airport operations.

Based on the assumption that in average, a 1 km decrease in distance to the airport leads to an noise exposure increased by approximately 7 to 8 dB, this value leads to a NDI estimate ranging from a 1.05% to 1.28% decrease in property value per dB increase in noise exposure. This estimate of the NDI for Beijing Capital International Airport is consistent with other NDI studies, even if it seems on the high side compared to other international NDI studies. That may be explained by the fact that Beijing Capital International Airport has a particular status, as it is the world's second busiest airport in the world. It may explain why the NDI estimate is higher than expected. Table 4 presents the NDI estimates for the world's busiest airports, based on the summary of NDI estimates by Wadud [7].

**Table 4.** Summary of NDI estimates for the busiest airports

| Rank (2011) | Airport | NDI estimate |
|---|---|---|
| 1 | Atlanta (Hartsfield-Jackson) | 0.67 (1985) |
| | | 0.08 (2003) |
| | | 0.69 (2006) |
| 2 | Beijing Capital International Airport | 1.05 to 1.28 (this study) |
| 3 | London (Heathrow) | 0.71 (1970) |
| | | 0.62 (1975) |
| | | 1.51 (1996) |
| 4 | Chicago (O'Hare) | 0.88 (2004) |
| 5 | Tokyo International Airport | No data |
| 6 | Los Angeles International Airport | 1.80 (1971) |
| | | 1.26 (1994) |

It seems that NDI estimates for the busiest airports are generally above the average. It is easy to understand that a busier airport has to manage more passengers, so it has to be larger in order to contain all infrastructures and runways. This larger airport necessarily generates more noise pollution. This can explain why the NDI estimate for BCIA is so high, since most of airports studied in the literature are smaller airports.

In China, airports are particularly large. The busiest seven airports with an annual passenger capacity of over ten million (Beijing, Shanghai Pudong, Guangdong, Shanghai Hongqiao, Shenzhen, Chengdu and Kunming) – that account for only 5 percent of all airports in China – represent 54.2 percent of China's total airport volume. In order to manage the growth of the Chinese population, the government plans to build larger airports[3] instead of many small airports. This is consistent with the hypothesis that airport noise pollution is more important in Chinese cities.

According the assumption that NDI and wealth are positively correlated, as China is still a developing country, the estimate of the NDI for BCIA should be lower than in the U.S. and in Canada. But the results of this study are not consistent with this assumption, suggesting that people of different wealth are willing to pay the same amount to avoid aircraft noise.

## 5 Conclusion

This paper analyzes the negative externality of Beijing Capital International Airport by examining the impact of aircraft noise on property values located close to the airport. According to the results of this study, aircraft noise severely impacts residential areas near BCIA. More precisely, if the distance between a property and the airport decreases by 1 kilometer, the property value ceteris paribus decreases by 8.4% to 8.96%. Then, we derive an approximate Noise Depreciation Index ranging from 1.05% to 1.28% per dB.

We should perform a survey of people living close to Beijing Capital International Airport in order to gather information related to perceived annoyance caused by aircraft noise. This would enable us to estimate more accurately the NDI, and then compare this standardized value to NDI estimates in other countries. In addition, we found no evidence that NDI tends to be lower in less developed countries. But China may be a particular case since Chinese airports are particularly large.

This study presents, however, some limitations. We have supposed that aircraft noise can account for all the negative effect of the distance to the airport on the variation in housing price, whereas it is obviously not the case. In addition, our dataset is relatively poor, and does not include enough variables. In the wake of the rapid development of geographical information systems (GIS), variables including proximities to transportation lines, retail outlets and green spaces could considerably improve the quality of data. Further research should focus on the actual influence of aircraft noise on the distance to the airport, as well as more consideration

[3] For example, Beijing plans to build its third airport in Daxing District, this airport is expected to overpass Atlanta Hartsfield-Jackson as the world's busiest airport.

about other sources of noise pollution (e.g. highways and railways) that can also affect house prices.

At the end of the year will begin the construction of Beijing's second international airport in the South of the metropolitan area. It is expected to become the world's busiest airport. This huge construction project will require to relocate thousands of people, and may more will live close to this airport. Knowing the environmental value of aircraft noise pollution can enable the government to compensate people who will suffer from the construction of this project, in order to ensure the population's welfare and fairness.

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