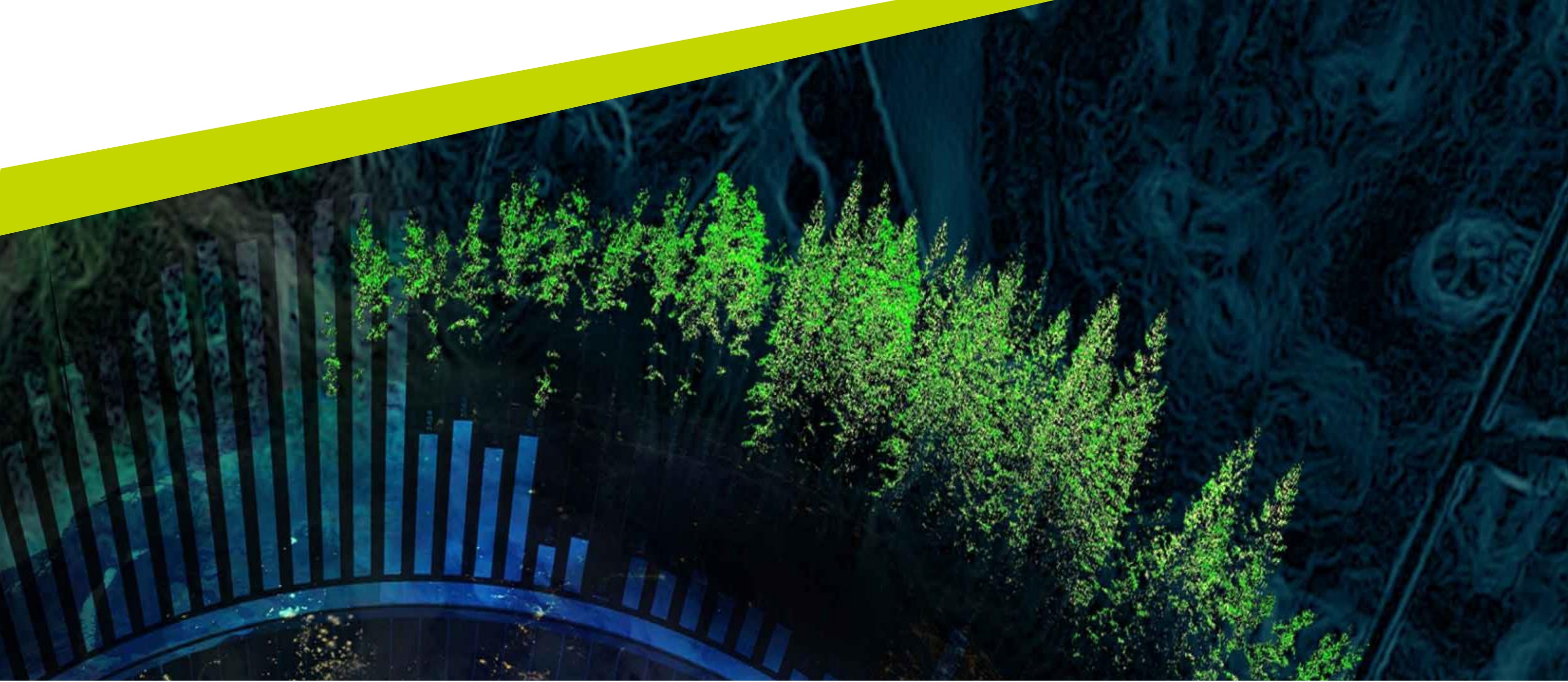
Assessing the Impact of Ocean Proximity and a Nuclear Power Plant on Property Values

A Hedonic Price Study in Östhammar

Louise Nordmark Strandberg

Degree project/Independent project • 15 credits
Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agriculture Sciences/Department of Economics
Business and Economics – Sustainable Development
Degree project/SLU, Department of Economics, 1537 • ISSN 1401-4084
Uppsala 2023



Assessing the Impact of Ocean Proximity and a Nuclear Power Plant on Property Values. A Hedonic Price Study in Östhammar

Louise Nordmark Strandberg

Supervisor:	**Tabaré Capitán Jiménez, Swedish University of Agriculture Sciences, Department of Economics**
Examiner:	Rob Hart, Swedish University of Agriculture Sciences, Department of Economics

Credits:	15 credits
Level:	First cycle, G2E
Course title:	Independent project in Economics
Course code:	EX0903
Programme/education:	Business and Economics – Sustainable Development
Course coordinating dept:	Department of Economics
Place of publication:	Uppsala
Year of publication:	2023
Copyright:	All featured images are used with permission from the copyright owner.
Title of series:	Degree Project/SLU, Department of Economics
Part number:	1537
ISSN:	1401-4084

Keywords:	Hedonic pricing, property prices, natural environment, Nuclear power plant, coastline

Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Economics

Abstract

This study examines the impact of environmental attributes, specifically proximity to the ocean and a nuclear power plant, on property prices in Östhammar municipality during the period of 2017-2022. By conducting a hedonic price model for evaluating non-market goods, a dataset of 1210 observations of family houses and vacation homes was analyzed. The dependent variable in the model was the price of sold property, which included house characteristics and distances to environmental attributes. The analysis involves the conducting of regression analyses with robust standard errors and a logarithmic model to represent the elasticity. The result revealed a significant negative relationship between distance to the ocean and property prices, indicating that properties closer to the coastline commanded higher prices. Conversely, the distance to the nuclear power plant and property prices were observed, indicating a positive significant relationship that when increasing the distance from the power plant resulted in higher property prices.

Keywords: Hedonic pricing, property pries, natural environment, Nuclear power plant, coastline

Table of contents

List of tables

1. Introduction

The first section of this paper is presented with an introduction of the subject, followed by the research question and hypothesis. Further, a literature review of previous studies will be presented when modeling hedonic price models and environmental amenities.

1.1 Background

The importance of preserving and including the environment in decision-making for society is arguable since individuals can appreciate it simultaneously. However, there are numerous reasons why it is crucial to consider the environment. Exposure to nature has positive effects on both mental and physical health, contributing to well-being through non-material values such as water filtration, pollination and carbon storage (Görlin, K., et al 2017).

In 1980 the youngest nuclear power plant started to operate in Sweden, situated near the coastline of the Baltic Sea in the municipality of Östhammar. This plant consists of three separate boiling water reactors, generating approximately one-sixth of Sweden's total electricity (Vattenfall). Compared to fossil fuels, nuclear power plants produce a significant amount of energy while having a smaller impact on greenhouse gas emissions. This makes it challenging to find a substitute that is equally environmentally friendly. However, the presence of a nuclear power plant may lead to negative perceptions and leading to reduced property prices based on individuals associated with the risks of living in proximity to one (Clark,. et al 1997).

Environmental goods can either have positive or negative externalities, as their costs and benefits are not accurately reflected in the market prices. Consequently, environmental services are considered non-rival goods, meaning that one individual's use of them does not diminish their availability to others. Although there is no direct market for these goods, they are indirectly valued using the hedonic price method, to consider the impact of environmental amenities on the prices of other goods. Research has shown that properties located close to environmental amenities such as parks, green fields, and lake areas tend to increase in value (Sander & Polasky, 2009). In today's dynamic real estate market, determining property values is a complex task influenced by numerous factors.

Properties in the same neighborhood can command different prices based on various considerations. Understanding the relationship between hedonic pricing, environmental attributes and human factors not only sheds light on the economic valuation of properties but also addresses critical concerns related to sustainability and social equity.

1.2 Research question and Hypothesis

This study aims to investigate the impact of proximity to a nuclear power plant and distance to the ocean on property prices in the municipality of Östhammar, Sweden. To determine the willingness to pay (WTP) living close to environmental attributes in a municipality where a nuclear power plant is running, an estimate of the implicit prices will also be provided. This research seeks to answer the following question:

Do property prices with closer proximity to the ocean result in higher prices independent of closeness to a nuclear power plant?

The hypothesis of this study is that property prices will have a positive effect with increasing prices when the distance to the coastline of the Baltic Sea decreases. Conversely, the properties' prices will decline as the proximity to Forsmark's nuclear power plant increases. It is believed that the distance to shopping facilities in rural areas shows a significant impact on property prices.

1.3 Literature Review

In previous literature, numerous studies have examined the relationship between environmental characteristics on both positive and negative externalities, particularly in relation to property prices. In the realm of positive externalities, research has explored how certain environmental attributes with a measurement of using the Hedonic price model can measure the monetary value to property prices on non-market goods.

A study conducted by Jim and Chen (2009) investigates the variety of environmental attributes on property prices using a hedonic price model. Through conducting a regression analysis with property prices as the dependent variable, they found that properties with a sea view experienced a positive effect leading to an increased property value of 2.97%. However, properties with a mountain view had a negative impact, resulting in a decrease in price by 6.7%.

The hedonic price model is also used to estimate cultural ecosystems and their economic values in Dakota by Sander and Haight (2012). They examined the effects on property prices when studying three different ecosystems and their associated services, outdoor space, scenic quality, and forest cover. Their result provides through two different models, one using hedonic prices with ordinary least squares and the second model for implicit marginal prices for ecosystem services. Unaffected surfaces positively influence home sale prices, total view area, and some land covers. Furthermore, the presence of surrounding forest cover had a significant positive impact, particularly in terms of access to outdoor spaces. Similar to a previous study, Sander and Plasky (2009) investigate how environmental amenities for open space access and view quality affects residential property prices in Minnesota. Their findings indicated a significant positive effect on property prices with respect to the proximity of parks, trails, lakes, and streams. Their result indicated that when increasing the distance to a park or a lake, the property prices would, therefore, have a negative impact. The authors emphasize the importance of cultural ecosystem services to residents and their willingness to pay for such amenities.

Schläpfer., et al. (2015) examined the valuation of landscape amenities, including parks, forests, and countryside views, on housing rents in Switzerland's urban, suburban, and periurban areas using a hedonic price analysis. Their results showed a positive association between these amenities and housing rents. Views of the countryside did also have a positive association. Conversely, closer distances to heavily trafficked roads and industrial areas had a negative impact on housing prices.

In the context of nuclear disasters, Tanaka and Zabel (2018) investigated the impact of the Fukushima disaster on housing prices in the USA. Their findings indicated that the effects of the disaster were primarily observed in the short term, leading to a temporary disruption in housing prices. However, over a longer period, housing prices gradually stabilized and returned to their pre-disaster levels. In contrast, Ando., et al. (2017) demonstrated that the Fukushima nuclear disaster had no significant impact on housing prices near nuclear power plants in Sweden when comparing housing prices before and after the Fukushima disaster in March 2011.

To address whether nuclear power plants influence residential property prices in California, Clark., et al. (1997) conducted two separate hedonic price models for two power plants. Their results indicated varying reactions depending on whether the scenic view of the power plant was visible or not, even if the plant was no longer operational. Different attitudes towards risks, uncertainty, and safety explain the concerns regarding potential negative externalities, such as nuclear waste. Similar to uncertainty, Jim and Chen (2009) attributed the negative relation between mountains and property prices to a lack of awareness among individuals regarding the positive attributes of mountains and their ecosystems.

Previous literature shows how the hedonic price model has shed light on the influence of environmental attributes on property prices. Additionally, some literature has also examined property prices in proximity to a nuclear power plant to assess the willingness to pay and the characteristics that affect property prices with hedonic price valuation. Therefore, given the presence of a nuclear power plant in the municipality of Östhammar, situated close to the coastline of the Baltic Sea, this paper aims to further investigate the effect of how the proximity of these two attributes can affect property prices.

2. Methodology

To find out factors affecting property prices and willingness to pay, a Hedonic price model will be used; following section will describe the principal theory of the hedonic price model for estimating the implicit prices for properties in Östhammar municipality.

2.1 The Hedonic Price Model

The hedonic price method is an economic approach used to estimate the implicit value or price of individual characteristics or attributes of a good, such as properties and was provided by Rosen (1974). It provides insights into preferences of buyers and willingness to pay for desirable features like number of rooms, size of the property and further characteristics (Brännlund & Kriström 2015).

In this model the first assumption is that it should have perfect information from sellers to buyers. One of the assumption in this model, is that each house has its own individual set of characteristics and that these all have an implicit price. Another assumption is that the consumer always strives to maximize their utility. (Brännlund & Kriström 2015)

This is when buying the optimal house the utility is maximized, in the same line as the lagrangian maximization on all other goods. Given the utility function $\mathrm{U}(\mathrm{z}_1\mathrm{z}_2\mathrm{..}, \mathrm{z}_\mathrm{n}, \mathrm{x})$ Where the household is maximizing its utility (U) depending on all other goods (x) followed byhousing attributes (z). The consumers budget constraint is given by $y = p(z) + x$ Where the income of the consumer is denoted as (y), the price of the good p(q) and x is all other goods. By taking the derivative of the price function with respect to the attribute gives the marginal willingness to pay for an attribute: $\partial P/\partial zi$ (Rosen 1974)

The basic hedonic model proposed by Rosen (1974), with the price as the dependent variable are represented as followed and are estimated by ordinary least squares:

$$Pi = \beta_0 + \beta_1 \times q_1 + \beta_2 \times q_2 + \cdots \beta_n \times q_n + \varepsilon_i$$

Where (Pi) stands for the price of each house i and in the end of the regression denoted with ε_i represents the error term capturing unobserved factors affecting the price that are not accounted by included characteristics.

Estimating by ordinary least squares (OLS) minimize the sum of squared differences between the observed observation and dependent variable based on independent variables. This results in the OLS estimator determines the regression coefficients in such way that the estimated regression line closely approximates the observed data (Stock and Watson 2020).

The estimated coefficients can be interpreted as the marginal contribution or implicit price associated with each characteristics. The magnitude of the coefficients represents the size of the price effect associated with a one unit change in the respective characteristics (Rosen 1974).

Applying a natural logarithm on both the dependent and independent variables are referred to as a log-log model, given a 1% change in independent variable is associated with a $\%\beta_1$ in the dependent variable keeping all the other variables constant (Stock & Watson 2020). An interpretation of implicit prices in the log-log form allows for the estimation of elasticities to procide insights into the percentage change in price associated with changes in the characteristics of the good or service (Rosen 1974).

3. Application

3.1 Case Study Area

Östhammar municipality is located in the northern region of Uppland, and spans an area of 3 486 km^2. The center of the municipality is approximately 60 km away from Uppsala and around 130 km from Stockholm, the capital of Sweden. As of 2022, the population of Östhammar municipality was approximately 22 344, showing a minor population growth of 417 since 2017 (SCB 2023). Many properties in the municipality serve as vacation homes owned by individuals from other regions.

In terms of income, the median income in Östhammar municipality in 2021 was approximately 306 619 SEK. By comparison, Uppsala municipality had a median income of 310 876 SEK, while Stockholm municipality had a higher median income of 357 677 SEK (SCB).

A rich and diverse ecosystem surrounds this area, together with a variety of nature scenery including approximately 40 nature reserves and marine habitats. Additionally, Östhammar is home to a stretch of the Baltic Sea coastline, extending up to 4000 km and featuring several small islands. One notable island within the municipality is Gräsö, which is the tenth largest island in Sweden, measuring 30 km in length and 6 km in width. It is inhabited by approximately 800 permanent residents (Roslagen). The Baltic Sea is a mixture of salty ocean and freshwater resulting in one of the worlds largest brakish water. It is surrounded by nine countries: Denmark, Germany, Poland, Lithuania, Latvia, Estonia, Russia, Finland and Sweden. While it supports a diverse ecosystem, the Baltic Sea is also threatened by biodiversity loss resulting from climate change and ocean pollution. (European commission)

In addition to environmental attributes in this area, Östhammar is also home to a nuclear power plant, Forsmark. In early 2020, the Swedish Government, in collaboration with the Swedish Radiation Safety Authority (SRSA) decided new planning areas around Swedens nuclear power plant; one inner zone and one outer zone of a distance of 5,25 and 100 km. Iodine tablets are given to each household within the area and a warning radio to prepeare if an incident would accur as an international requirement and a lesson after the Fukushima accident. (SRSA)

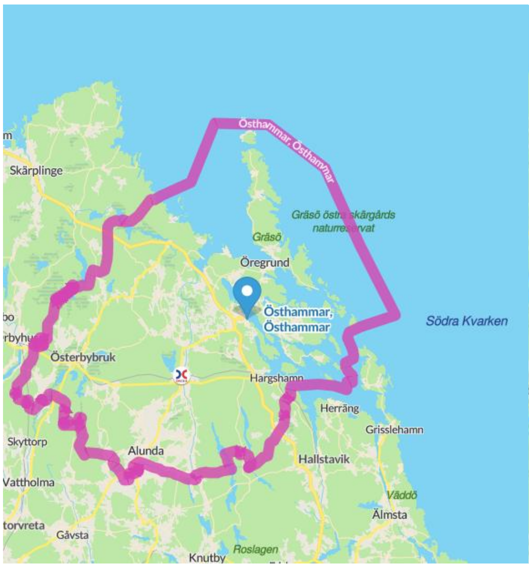


Figure 1. Map over study area, hitta.se (2023)

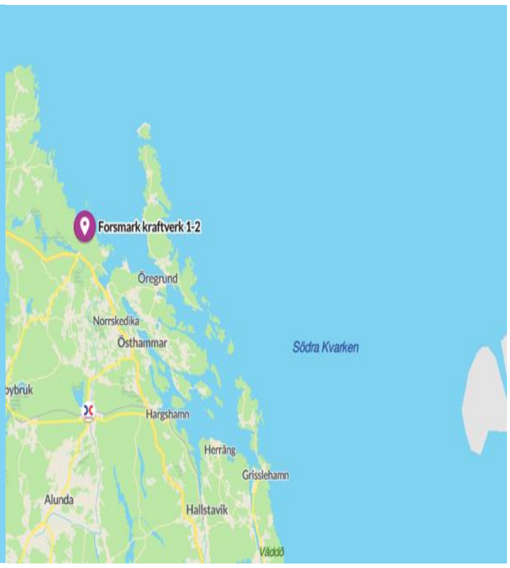


Figure 2. Forsmark location, hitta.se (2023)

3.2 Data

Data on properties were agreed upon and received from Mäklarstatistik of Sweden, a website that provides residential property sales prices from real estate agents with information on different property characteristics. Additional data were collected from Booli, a public website on residential property prices, and Statistics of Sweden. The data covers sold properties between 2017 to 2022 in the municipality of Östhammar, where house characteristics include the living area, number of rooms, age of the property, plot area, and bi area. Time series data is used, allowing the analysis of a single entity over multiple time periods (Stock and Watson, 2020:51). The distance was gathered using Google Maps from each sold property to the coastline of the Baltic Sea, numerous municipal beaches and, nearest shopping area. These distance measurements were manually recorded by hand for each observation. The distance to the nuclear power plant was calculated using geographic coordinates in STATA, all of the measurements units in the used data set are in swedish kilometers. A dummy variable for Covid was created in STATA based on yearly data, capturing the impact of the pandemic on property prices. Additionally, a dummy variable indicating the type of water used at each sold property was manually created using information provided by Booli,

The data set consisted a total of 1498 observations, where 280 observations were omitted from the analysis due to missing values in certain variables.

To account for inflation, the selling prices were adjusted with the consumer price index (CPI), obtained from statistics of Sweden (SCB), with 2017 as the base year. The adjusted CPI is calculated by dividing each year by the CPI from 2017 in STATA to compare the properties with each other and are presented in Table 1.

Table 1. Consumer Price Index

	2017	2018	2019	2020	2021	2022
CPI	317.50	322.51	328.56	332.82	338.09	350.56
Adjusted CPI	1	1.015779	1.034835	1.048252	1.06485	1.104126

3.3 Variables

Adjusted selling price, represented as the dependent variable applied in a logarithmic form. Variables are expected to have a declining impact as their values increase, an incentive for conducting a natural logarithm (Sander & Haight, 2012). The independent variables are divided into two groups: house characteristics and environmental attributes. Distance to the Forsmark nuclear power plant was measured using STATA based on gathered coordinates,while other distance measurements were manually recorded for each sold property within the municipality. Swedish Krona (SEK) will display all sales prices and calculations.

Property characteristics variables of interest includes the number of rooms in the property, living area in square meters, bi area in square meters (according to Swedish tax agency its representing additional space beyond the living area, such as garage, storage space, and boiler room, and limited to a height of less than 190 cm), lot area in square meters, and age of the property (where the year of construction was subtracted from 2022). The type of water is represented as a dummy variable, indicating whether the property has its own well or receives water from the municipality. Covid-19 is also interpreted as a dummy variable, taking the value 1 for the years 2020-2022 to capture the impact of pandemic, and 0 if there was no Covid-19.

The environmental attributes include the distance to the coastline and Forsmark nuclear power plant. These measurments are based on straight-line distances, with a limitation that they do not account for crossing private properties or the availability of specific walking/driving paths.

Distance to the nearest beach and shopping area were also been measured manually. The beach variable represents beaches owned and maintained by the municipality of Östhammar, excuding small private or unofficial bathing areas where information regarding the ownership of these areas is not available.

In terms of expectaions, house characteristic variables such as the number of rooms and living area are anticipated to have a positive impact on property prices, while distance variables are expected to have a negative impact for positive environmental externalities and a positive impact for variables such as distance to Forsmark. These assumption are supported by the findings of previous literature.

Table 2. Summary statistics

Variable	Std.Dev	Mean	Median	Minimum	Maxiumum
Price Adjusted	1 110 448	2 138 804	1 900 000	235 000	9 000 000
Log Price Adjust	0.5050168	14.40764	14.41606	12.23022	15.99708
Nr Rooms	1.537862	4.2134	4	1	10
Living Area	44.81316	99.35694	94	16	365
Bi Area	38.84865	27.45272	5	0	222
Plot Area	6 114.674	3 155.508	2002	75	104 664
Age of House	39.32222	62.05289	51	1	321
Dist. Forsmark	8.257637	23.1245	22.01394	3.632442	42.55003
Dist.Ocean	10.21856	8.220946	1.3	0.02	38
Dist.Beach	4.932801	5.659511	3.8	0.1	27
Dist.Shopping	4.774116	4.77474	3.1	0	33
Water	0.4934643	0.5818182	1	0	1
Covid	0.5001897	0.5041322	1	0	1

The model with all variables, will look as following:

$$Ln\,P = \beta_0 + \beta_1 \times NrRooms + \beta_2 \times LivingArea + \beta_3 \times BiArea + \beta_4 \times PlotArea - \beta_5 \times AgeHouse + \beta_6 \times DistForsmark - \beta_7 \times Dist.Ocean - \beta_8 \times DistBeach - \beta_9 \times DistShops + \beta_{10} \times Water + \beta_{11} \times Covid + \varepsilon_i$$

Where ε_i is presented as the error term and expected to have the value of 0.

4. Results

In the following section the econometric results will be presented, implicit prices will be estimated with all the variables. Further, presenting the results for environmental amenities followed by test for econometric credibility of the model.

4.1 Model

Using the program STATA, the regression is computed with ordinary least squares (OLS) estimates. Robust standard errors were used to account for potential heteroscedasticity, ensuring more reliable and robust results. The model was completed in a log-log form, which is commonly used in hedonic price models, to account for the non-linear relationship between the independent and the dependent variable. The sample size for the analysis consisted of n = 1210, and significance levels for the variables in the model are: *** if p < 0.01, ** if p < 0.05, and * if p < 0.1. Model 3, presented in table 3, represents the final model, and for calculating the implicit price, each coefficient is presented together with its significance level and t-ratios in the parentheses.

Table 3. Regression results

Variable	Model 1	Model 2	Model 3	Model 3
lnForsmark	—	0.0402 (0.0534)	0.134*** (0.0359)	0.116*** (0.0361)
lnOcean	—	0.0989*** (0.0119)	-0.120*** (0.00793)	-0.117*** (0.00794)
Nr Rooms	0.0336** (0.0151)	0.0321** (0.0143)	0.0237** (0.0112)	0.0250** (0.0111)
lnLiving Area	0.560*** (0.0655)	0.546*** (0.0619)	0.539*** (0.0413)	0.544*** (0.0407)
lnPlot Area	0.0471** (0.0216)	0.0834*** (0.0243)	0.0928*** (0.0185)	0.0770*** (0.0175)
Bi Area	—	—	0.000172 (0.000289)	-0.000188 (0.000304)
lnBi Area	-0.00733 (0.0180)	0.00953 (0.0171)	—	—
Age of Building	-0.00248*** (0.000561)	-0.00166*** (0.000505)	-0.00135*** (0.000331)	-0.00136*** (0.000343)

lnBeach	—	0.137*** (0.0238)	0.115*** (0.0160)	0.117*** (0.0165)
lnShopping	—	0.102*** (0.0198)	-0.0764*** (0.0181)	-0.0990*** (0.0159)
X-Water	—	—	-0.0934** (0.0408)	—
X-Covid	—	—	0.146*** (0.0213)	—
Constant	11.53*** (0.294)	11.09*** (0.231)	10.84*** (0.231)	11.02*** (0.231)

This gives the calculated model as follow:

$$LnPrice = 10.84 + 0.134 \times lnForsmark - 0.120 \times lnOcean + 0.0237 \times Nr\ Rooms + 0.539 \times lnLiving\ Area + 0.0928 \times lnPlot\ Area + 0.000172 \times Bi\ Area - 0.00135 \times Age\ of\ Building + 0.115 \times lnBeach - 0.0764 \times lnShopping - 0.0934 \times X - water + 0.146 \times X - Covid$$

By taking the partial derivate of the price variable to calculate the implicit price for each attribute, each coefficient of the variables is multiplied with the mean adjusted price of 2 138 804 SEK. By doing so, this refers to the implied value or cost association with an attribute or characteristic. By conducting the model in log-log form, the implicit marginal prices will display the effect on sales price from a one-percentage change instead of a one-unit change in the attribute, keeping all other attributes constant. This result of the implicit prices are displayed in Table 4 are not conducted in a logarithmic form, showing the coefficient and corresponding implicit price for each variable.

Table 4. The implicit marginal prices

Varible	Coefficient	Implicit price
Nr Rooms	0.0237	48 445.2
Living Area	0.539	1 101 771
Plot Area	0.0928	189 692.6
Bi Area	0.000172	351.6
Age of Property	-0.00135	-2 759.5
Distance Ocean	-0.120	-245 292.2
Distance Forsmark	0.134	273 090.7
Distance Beach	0.115	235 071.7
Distance Shopping	-0.0764	-156 169.4
X-Water	-0.0934	-190 919
X-Covid	0.146	298 438.9

Running the model at different times interprets how robust the model and variables are. Model 3 is the full model with all variables included, with different of uses of the bi-area variable in its original form (not logarithmic). In the first model, only explanatory variables are used given a highly significant result. By adding variables for distance, the significance tends to be higher; the first and second models in Table 3 resulted in 633 observations. With 1210 observations, the difference in model 4 does not include any dummy variable. The results in later models show a negative distance to the ocean and a positive distance to Forsmark.

4.2 Analysis of the model

For the estimated coefficient, the results are within the expected hypothesis stated at the beginning of this paper. The interpreted coefficient at 10,84 is the intercept of constant indicating the estimated average of property prices when all the independent variables are set to zero and significant at 99%. The models result shows general significance but should be handled with caution. My calculated R-squared for the final model is moderate with a value at 0.474, a 47.7% explanation in the variation property prices based on included independent variables followed by 52.3 % of the variation attributed to other factors and not captured in the model. In model 1, with 633 observations on only house characteristics the R-squared resulted in 0.346. When including the distance variables in the regression for model 2, the observations are the same as in the first model but with a higher r-squared at 0.438. In the last regression for model 4, the dummy variables were omittied and resulted in a r-squared at 0.451. When conducting the hedonic price analysis, the goal is to understand the relationship between the price of a property and various attributes. The result in this paper is performed in a log-log model, implying that almost all of the variables are in natural logarithm except for the age of the property, number of rooms, and the bi area; it captures a non-linear relationship and improves the model of fit.

In the results, the distance to the coastline of the ocean coefficient is negative, implying that an increase in the distance to the ocean is associated with a decrease in property prices. A 1 % change in the increase to the distance is associated with a 0.12 % decrease in property prices. The negative relationship explains that properties closer to the ocean tend to have higher prices, indicating a positive value associated with the proximity to the coast.

The results of model 3 also say that with a one-unit increase in the number of rooms, the property price will increase by 0.0237%, holding all other variables constant. The living area is denoted as a natural logarithm, and the coefficient of 0.539 means that a 1 % increase in the living area is associated with a 0.539% increase in the price, suggesting a positive relationship. The biarea is showing a positive coefficient at 0.000172; although this coefficient is positive, it appears to be small, indicating a minimal impact on property prices. The age of the building is also showing a very small coefficient. However at a 99% significance implying, that a 1 % increase in the building's age is associated with a 0.00135 decrease in property prices.

Including Covid as a dummy variable the explanation of the model increased, a positive coefficient of 0.146 suggests that properties sold during the Covid period experienced an increase in prices compared to properties sold in the years 2017-2019. This could be explained by factors such as changes in the housing demand or government polivies during the pandemic.

The results also suggests that properties with a municipal water supply, assigned a value of 0, tend to have lower prices compared to properties with private or summer water sources. This result may be attributed to factors such as perceived quality or reliability of municipal water versus private water sources, with buyers showing a preference for properties owning a own well for private or summer water options.

4.3 Distance to the ocean

Environmental factors, such as proximity to the ocean, can have a substantial impact on property prices due to their desirability and associated amenitites. In the results, the distance to the coastline of the ocean coefficient is negative at -0.120, implying that an increase in the distance to the ocean is associated with a decrease in property prices. A 1 % increase to the distance corresponds to a 0.12 % decrease in property prices. This implies that individuals are willing to pay for properties closer to the ocean, with an estimated increase in property value of 245 292 SEK for a decrease of 1 kilometer in distance.

The negative relationship explains that properties closer to the ocean tends to have higher prices, indicating a positive value associated with the proximity to the coast. The result is likely due to factors such as scenic views, recreational opportunities, and access to bathing areas. However, for the distance to the beach the coefficient was positive, indicating that a decreasing distance to the beach would lower the property price with 235 072 SEK.

The results should be handed with caution since distance measurements in this study are based on a straight-line from each property to respective attribute.

Problems can arise if data points are drawn geographically, and might not reveal the true willingness to pay for the attribute (Perman et al 2011).

4.4 Distance to Forsmark

By adding a natural logarithm on the distance variables, it is modelling the percentage change in property prices with a percentage change in the distance. The positive coefficient of the distance to Forsmark suggests that an increase in the distance is associated with higher property prices in terms of elasticities. A 1 % increase in the distance from Forsmark corresponds to a 0.134% increase in property prices, suggesting a positive relationship. This implies that properties located further away from Forsmark command higher prices, with an estimated effect on sales price indicating an increase of 273 092 SEK. The estimated distance variable to shopping areas suggests that with a 1 km decrease the willingness to pay is estimated to an extra 156 169 SEK to the value of property.

It is important to recognize that when modelling the distance to Forsmark, there are several aspects to consider, including the surrounding areas and property characteristics that could influence the willingness to pay for living closer or further away from a nuclear power plant. Factors such as proximity to amenities, perceived safety, access to services, and individual preferences may interact with the distance variable to shape the actual effect on property prices.

4.5 Econometric credibility

A calculated R^2 of 0.474 implies that the model is explained by 47% of the variance in property prices which is a relatively low number and that the used variables are moderate for estimating the property sales prices. While this value indicates that the included variables are moderately effective in estimating property sales prices, it also implies that there are other factors not captured in the model contributing to the remaining 53% of the price variation.

By conducting a White’s test in STATA to examine the present of heteroskedasticity in the model, whether the squared residuals in the model are related to the independent variables. The results indicated significant relationships, suggesting the presence of heteroscedasticity. It is important to interpret the estimation results with caution due to potential impact of heteroscedasticity on the accuracy on the model.

To asses multicollinearity in the model the variance inflation factor (VIF) is used. The value of 1 indiciates no multicollinearity, while higher values indicates increasing values of the multicollinearity. A rule of thumb, when the values of VIF is greater than 5 is consider multicollinarity (Stock & Watson 2020).

In table 5, the distance to shopping is close to 5 indicating that an existence of multicollinearity between the distance and other independent variables in my model. The presence could be because distance variables can be correlated due to the proximity to each other.

Table 5. Variance Inflaction factor

Variable	**VIF**
Nr Rooms	2.61
lnLiving Area	2.79
lnPlot Area	1.96
Bi Area	1.33
Age of Property	1.14
lnDist Shopping	4.27
lnDist Ocean	1.88
lnDist Forsmark	1.52
lnDist Beach	2.35
X-Water	3.53
X-Covid	1.01

5. Discussion

By conducting the hedonic model for this paper, the result showed a significant number of variables to have a statistically significant impact on property prices. However, it is essential to consider the benchmark for assessing the R^2 value, which ranges from 0 to 1, with a higher value indicating a better fit of the model to the data measured in percentage of the response variable's variability. In comparison to established benchmarks for price variation models in this context, the obtained R^2 value of 47.4% is relatively low. This indicates that the explanation in the model in the variation of prices is moderate in relation to the benchmark. It is crucial to acknowledge that the interpretation of a "relatively low" R^2 is subjective. In this case, it could be due to the limitation of available variables and depending on the complexity of the real estate market. Potential reasons behind the remaining 52.6% of the unexplained variation could be due to market fluctuations and buyer preferences. The dataset obtained 1210 observations on family houses and vacation houses in Östhammar municipality during 2017-2022. The research question aimed to answer whether property prices are influenced by the proximity to the ocean, independent of the distance to a nuclear power plant.

The hypothesis was that an increase in distance to a nuclear power plant would increase property prices, and a decrease in distance to the ocean would also increase property prices. Given the results of the model the hypothesis is true, the distance variable for the power plant showed a positive coefficient implying that a decreasing distance would affect the property price negatively and increasing the distance to the ocean would also have a negative effect on property prices.

In terms of previous literature researchers could examine that properties closer to environmental attributes will increase property prices. Similar to Jim and Chen (2009), this paper found similar results in terms of increasing property prices closer to the coastline. Conversely, the main findings in my results were in line with Clark et al (2009) and the impact willingness to pay in the proximity to a nuclear power plant. Additionally, it is important to consider socio-cultural dynamics and individual preferences that could shape the desirability of living near a nuclear power plant.

To further enhance the results of this study, it would be beneficial to include additional variables such as income and conduct comparative analyses with other municipalities located near nuclear power plants. Due to no information on population registration regarding vacation homes, income variables were chosen not to be presented in the model. However, this would provide a broader perspective and give a more comprehensive understanding of factors influencing property prices in relation to both environmental attributes and socioeconomic factors.

The results show significance when considering environmental attributes, in terms of proximity to the ocean and a nuclear power plant, when assessing property values. These findings can inform policymakers for land use planning, zone regulations, and property development in coastal areas. By understanding the complex relationship between distance to Forsmark and property prices, a comprehensive examination in terms of sending out surveys or doing qualitative research to explore the attitudes, perceptions, and motivations towards a nuclear power plant in the municipality of Östhammar, to cover individual aspects in the model. This would provide deeper insights into the factors influencing decision-making processes.

It is important to acknowledge the limitations of this study, since the analysis was constrained by the available data and specific context. Future research should address these limitations by including additional variables by considering factors such as income, neighborhood characteristics, and infrastructure development and use a measurement for distance capturing the reality.

In conclusion, this study contributes to the understanding of factors influencing property prices in Östhammar municipality. In the results, the significance of proximity to the ocean and a nuclear power plant shows influential determinans of property values. By considering the implications of these findings for policymakers, the real estate market and potential buyers, the possibility to make a more informed decision in the real estate market. Further research can uncover insights and contribute to the ongoing development of individuals willingness to pay for properties surrounded by the environment.

References

Ando, Dahlberg & Engström (2017). The Risk of Nuclear Disaster and Its impact on Housing Prices. Economics letters, 154, 13-16. https://www.sciencedirect.com/science/article/abs/pii/S0165176517300629?via%3Dihub

Brännlund, R., & Kriström, B. (2015) *Miljöekonomi*. 2:a upplagan. Studentlitteratur AB, Lund.

Clark, D.E., Michelbrink, L., Allison, T., & Metz, W.C. (1997). Nuclear power plants and residential housing prices. *Growth and Change,* 28(4), 496-519. Available: https://www.researchgate.net/publication/227950288_Nuclear_Power_Plants_and_Residential_Housing_Prices (2023-03-22)

European commission. (n.d). Baltic Sea. Retrieved from https://oceans-and-fisheries.ec.europa.eu/ocean/sea-basins/baltic-sea_en?fbclid=IwAR1rlrLxrOitpE49oUJRmNJvxiHeF1-VJefp01tK8LFgufdIkvwW8749IqI (2023-06-03)

Görlin, K., Persson, A., Jönsson-Belyazid, U., Hansson, J., & Soutukorva, Å. (2017). Argument för mer ekosystemtjänster. *Report 2017*, *6736*. https://www.diva-portal.org/smash/get/diva2:1072561/FULLTEXT01.pdf (2023-03-20)

Jim, C. Y., & Chen, W. Y. (2009). Value of scenic views: Hedonic assessment of private housing in Hong Kong. *Landscape and urban planning*, *91*(4), 226-234. https://www.sciencedirect.com/science/article/pii/S0169204609000115?casa_token=ELfBiftBnuoAAAAA:qUA1nYuirg2_3-UUEFAXnsRuVcbMlaQBMZ2QDAnQgGBYeW1P_wxto9dAORzCP1mYGWjhcY_rpQ (2023-03-18)

Perman, R., Ma, Y., Common, M., Maddison, D. and McGilvray, J. (2011) *Natural Resource and Environmental Economics*. 4th edition. Harlow: Pearson.

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, 82 (1), 34-55.

Roslagen (2020) *Östhammar - aktiviteter*
https://www.roslagen.se/osthammar/aktiviteter

Sander, H. A., & Haight, R. G. (2012). Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. *Journal of environmental management*, *113*, 194-205.
https://www.sciencedirect.com/science/article/pii/S0301479712004392?casa_token=_crfOnykZfkAAAAA:5elG114nXkyu85id3z7vgHx7Rdju0FyxuN6-gP3ryOUr0R4VHXJPUl58ECn26skkvMtIss2ujA

Sander, H. A., & Polasky, S. (2009). *The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. Land Use Policy*, *26*(3), 837-845.
https://www.sciencedirect.com/science/article/pii/S0264837708001324

Schläpfer, F., Waltert, F., Segura, L., & Kienast, F. (2015). Valuation of landscape amenities: A hedonic pricing analysis of housing rents in urban, suburban and periurban Switzerland. *Landscape and Urban Planning*, *141*, 24-40.
https://www.sciencedirect.com/science/article/pii/S0169204615000833?casa_token=pBXygbl_dnEAAAAA:h_bXzg7NtyySUGnPafwa40tV36bm2gDdMc9qrO2l2hRSB0e2ZEI2lLhrLpVV-I2GT-POuonwtQ

Statistics Sweden. *Inkomster för personer I Sverige.*
https://www.scb.se/hitta-statistik/sverige-i-siffror/djupdykning-i-statistik-om-sveriges-kommuner/ (2023-06-01)

Stock, J.H & Watson, M.W. (2020). *Introduction to econometrics.* Fourth edition, Global edition. Harlow: Pearson.

Svensk Mäklarstatistik (2023) *Bostadspriser i Östhammar*
https://www.maklarstatistik.se/omrade/riket/uppsala-lan/osthammar/#/fritidshus
(2023-03-12)

Swedish tax agency (n.d). *Så mäter du ditt småhus.*
https://www.skatteverket.se/privat/fastigheterochbostad/fastighetstaxering/deklarerasmahus/matreglerforsmahus.4.5cbdbba811c9a768f0c80002011.html (2023-05-26)

Tanaka, S., & Zabel (2018). Valuing nuclear energy risk: Evidence from the impact of the Fukushima crisis on U.S house prices. *Journal of Environmental Economics and Management, 88, 411-426.*
https://www.sciencedirect.com/science/article/abs/pii/S0095069617301626

Acknowledgements

I would like to thank my supervisor Tabaré Capitán Jiménez for his support and guidance throughout my study and responsiveness to my questions. I am also grateful to my parents and boyfriend for their constant encouragement and belief in my abilities helping me to navigate the challenges and uncertainties of this journey. Lastly, I would like to extend my thanks to my friends for their support and applause.

Publishing and archiving

Approved students' theses at SLU are published electronically. As a student, you have the copyright to your own work and need to approve the electronic publishing. If you check the box for **YES**, the full text (pdf file) and metadata will be visible and searchable online. If you check the box for **NO**, only the metadata and the abstract will be visible and searchable online. Nevertheless, when the document is uploaded it will still be archived as a digital file. If you are more than one author, the checked box will be applied to all authors. You will find a link to SLU's publishing agreement here:

- https://libanswers.slu.se/en/faq/228318.

☒ YES, I/we hereby give permission to publish the present thesis in accordance with the SLU agreement regarding the transfer of the right to publish a work.

☐ NO, I/we do not give permission to publish the present work. The work will still be archived and its metadata and abstract will be visible and searchable.