Proximity to Water and Residential Property Values: Evidence From The Netherlands

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ABSTRACT

Water has aesthetic and recreational values, and health benefits, but can also bring a risk of flooding towards homeowners. This paper studies the effect of distance to water on residential property prices by using GIS measures in a pseudo-repeat sales model for over 185,000 transactions in 2019 in the Netherlands. When compared to properties nearby water (distance < 25m), there is a 1.91% discount in price for properties that have a 25-50m distance to nearest water. This discount can go up to -4.04% on average, for properties with 200-400m distance to nearest water. The robustness differentiated for type of property also remains stable. The size of the effect is sensitive to the type of water, but overall shows an increasing negative effect as distance increases. Concluding that properties nearby water sell at a premium relative to properties further away from water. As urbanization and climate change strengthen the need for water management and a maximization of benefits for society, the correct valuation of water is important for policy makers to make cost-benefit decisions on land use through spatial planning.

Keywords: proximity to water, house prices, hedonic pricing model

1. INTRODUCTION

In the 20th century the usage of water has notably changed. In the past waters main use was for agricultural and industrial purposes, uses which due to technological advancements became abundant (Rosenberg & Birdzell, 2008). In present day, water is associated with aesthetic and recreational use, or improving a general quality of life (Cohen et al., 2015). Proximity to these benefits result in human pleasure and momentary happiness, and with it positive effects on health (Benita et al., 2019; Smith et al., 2021; Lauwers et al., 2021). Besides benefits, there are also downsides to proximity of water, for example, a risk of flooding which can have great destructive power to the surroundings.

In order to ‘capitalize’ these effects, a link between economy and ecology can be found in the premium that properties in an attractive setting have when compared to properties in a less attractive setting (Luttik, 2000). The premium being the willingness to pay for (proximity to) the positive external factors. The same reasoning can be used for negative external factors, such as risks for flooding for example, resulting in a discount in price (Zhang & Leonard, 2018; Bosker et al., 2019). Residential property prices are built-up of multiple internal property characteristics and external environment characteristics (May et al., 2011).

A method that uses property prices to capitalize certain characteristics is the hedonic pricing model, which for that same reason is commonly used by environmental economists (Olmstead, 2020)[1]. Hedonic models are able to decompose a properties transaction price into individual prices for characteristics that specified in the model. Earlier hedonic literature on the effects of water on residential property prices are relatively scarce compared to other amenities such as transport stations, schools or parks (Crone, 1998; Daams et al., 2016; Trojanek & Gluszak, 2018). Even in a country shaped by water, the Netherlands, its effects are a relatively overlooked subject by the Dutch academic world. To the best of current knowledge, the Dutch literature regarding effects of water is scarce and dated. One of few Dutch studies which has considered water to hold value is Luttik (2000). Luttik (2000) finds that properties adjacent to lakes have the highest premiums, up to 12%. For properties nearby, but not adjacent to, waterthe price premium declines to around 5%. The only found Dutch studies regarding explicitly the effects of water on property prices within this decade consists a study by Rouwendal et al. (2017) of and some student theses (Roosendaal, 2017; Koster, 2021). The

[1] A method which makes use of the build-up of specific property and environment characteristics is the Hedonic Pricing Model (Rosen, 1974). The models is able to determine the intrinsic value of individual attributes of properties Monson (2009). Important to note are the models assumptions which state that the housing market is operating under perfect competition, having plenty of buyers and sellers that have freedom to enter and exit, and have perfect information, and lastly requires homogeneity of the product (Chau & Chin, 2003).

study by Rouwendal et al. (2017) finds that proximity to water can increase a property's value by roughly 4% to 6% for the properties closest to water. They find no statistical significant differences between the valuation of different types of water in most models. These results are substantially lower than the 5% to 12% found by Luttik (2000). Rouwendal et al. (2017) only use larger cities with hand-selected neighborhoods, and limit the effects to 100 meters whereas this study differentiates in scale, target area and range of the effect. The vast array of academic findings regarding the valuation of water amenities are international (for example David, 1968; Moore et al., 2020). Boyle & Kiel (2001) conclude that the quality of water also matters for the price-effect. Due to large differences between countries, for example in water management and use, these international results cannot be directly generalized for the Netherlands. The Netherlands is a country abundant in water, while enjoying the benefits for this abundancy it also brings increased risks, since most of the Netherlands is located below sea level. Therefore, it's possible that the Dutch valuation of water is different compared to water-scarce countries. This paper fills in this research gap by examining the relationship between property distance to water and residential property prices in the Netherlands for the year 2019.

The presence and size of the price differential is potentially important for policy makers in order to maximize the well-being of its residents, through spatial planning. Urbanization can conflict with natural amenities due to the relatively unknown values of natural amenities compared to functions with a clearer monetized value (Nuissl & Siedentop, 2021). In addition, the knowledge of the valuation of water within residential properties can be of use to professional values and homeowners- and buyers in order to correctly value these properties. A final issue, which is becoming increasingly more relevant to study the effects of water, is climate change. The climate is changing, resulting in more droughts and heavy rain bursts for example (IPCC, 2022). Therefore, the climate adaption of the built environment is becoming increasingly important. Water management is playing a growing role in urban resilience and towards combatting the climate change consequences (Muller, 2007). Therefore, water can have a dual-function, providing amenities and well-being for residents while also reducing the risk of some climate change consequences. Which makes it a valuable tool for land use planners that at the same time requires precise valuation for policy makers' analysis.

The research aim of this paper is to explore whether and to what extent a residential property's distance to water affects the property's transaction price, and how this effect behaves spatially. To accomplish this aim, the following main research question is formulated: 'What is the relationship between distance to water and residential transaction prices in the Netherlands?'. The relationship is studied by implementing Geographical Information Systems

(GIS) measures, combining the mapped water information with approximately 187,000 Dutch single-home property transactions in 2019. The property transactions are retrieved from the Dutch Association for Real Estate Agents (NVM). The mapped water data is retrieved from the 'Basisregrestratie Grootschalige Topografie' (BGT), created by the Dutch government. The distance to nearest body of water from the BGT map to the location of individual transactions is done using GIS. The combined dataset is then analyzed using a pseudo-repeat sales (Ps-RS) model, which groups the transactions at postal code-4 level for spatial fixed effects. The benefits of this model is that it cancels out local similarities by using spatial differencing in order to reduce omitted variable bias, making it a preferred approach to purge the influence of variables that might be locally correlated with environmental variables (Daams et al,, 2019).

The result of the analysis adds to the literature of understanding the effects of distance to water on property prices, which is also of use for policy makers for land use planning and cost-benefit analysis. Since a large share of studies in house price variations focus on regional surroundings this paper differentiates by enlarging the study area to the whole of the Netherlands. When taking the existing literature into account, one would expect that the benefits of water result in a price premium (Luttik, 2000). This can be different for locations where water brings risks of flooding (Zhang & Leonard, 2018). However, in the Netherlands these risks are limited, therefore one can expect the benefits to exceed the risk, resulting in a price premium (PBL, 2014). When taking a closer look at the distance effect, the expectations are that the closer to water the property is, the higher the premium (Mahan et al., 2000; Tapsuwan et al, 2009). Therefore, the expectations of the effect of water on property prices are positive, the size of the effect however remains hard to predict, as earlier results vary (Luttik, 2000; Rouwendal et al., 2017; Roosendaal, 2017; Koster, 2021). Whether effects differ for type of water also show mixed results in the literature (Mahan et al., 2000). The abovementioned results in the following hypothesis: proximity to water is valued positively roughly between 4% and 12%. As a second hypothesis: there is no significant difference in the effect for different types of water.

The remainder of this paper is organized as follows. The next section describes the empirical approach. Section 3 describes the data and section 4 presents and discusses the results. Section 5 concludes.

2. METHODOLOGY

2.1 Study design

This research aims to capture the indirect values of water as reflected in residential property prices. The values are indirect, since distance to water is not considered to be a marketable good - it is not possible to simply buy or have a price for 'one canal' once a property is bought - while it is possible to simply buy or receive a price for a dormer for example. Since these indirect values cannot be measured directly, other methods must be used. Residential property prices consist of both internal-property and external-surrounding effects, and are often used to measure these indirect values. Therefore, residential property prices are used to estimate the value, either being not present, a premium, or discount that buyers are paying for proximity to water. The study area consists of the Netherlands. This study examines 187,547 residential transactions across the Netherlands for the year 2019. The property characteristics and transaction data are retrieved from the NVM, which will be discussed in chapter three. The model used to analyze the data is discussed further below. For linking data of the properties to location QGIS is used. Geographic Information Systems (GIS) is commonly used for spatial data analyzing or editing in similar studies (Cunningham, 2006; Filippova, 2009; Kong et al., 2017). The water-data is retrieved from BGT. The variable of interest, distance to water, is retrieved while also capturing the characteristics of the nearest water feature, including the type of water. With this information, categories of distance can be made in order to study the effect over different ranges of distance. This study uses the same categories for water types as the Dutch Land Registry and Mapping Agency, being water courses, canals (type 'gracht' and type 'kanaal'), harbors, lakes and rivers.

2.2 Hedonic specification

To study the abovementioned relationship between water and residential property prices a hedonic multivariable regression is used. Specifically, the pseudo-repeat sales (Ps-RS) model, which is similar, but stricter than, the standard hedonic pricing model as it applies spatial first differencing to the data (Daams et al., 2019). As Daams et al. (2019) note, spatial differencing is used to reduce omitted variable bias. The spatial differencing pairs houses that have the same spatial scale (e.g. postal code levels) and is used to reduce said omitted variable bias by cancelling out similarities in the prices which can be ascribed to location. This analysis includes the proximity to water variable for transactions combined at 4-digit postal code level. Since transactions are grouped at 4-digit postal code level, the assumption is made that within that postal code level amenities are similar, and differences in price therefore can be ascribed to differences in property specific characteristics and other specific known variables of interest , such as distance to water. Since the latter is known individually, the Ps-RS model can filter out the differences for said variable. By cancelling local similarity unobserved variables bias is reduced, making it suitable for a large-scale study.

The dataset holds information on distance to nearest water and specifies the type of water. A base model is set that studies the effect of proximity to all types of waters. The distance to water is categorized to comprehensively and granularly catch the distance. The used distance categories are set on the best fit for the base model. After the base model is set, models (2) to (4) are tested using all the same variables as the base model, but are ran separate for distance to specific types of water to see if the effect of water differs for specific types of water. Model (2) only takes distance to water courses (in Dutch 'sloot'), model (3) to lakes/ponds and model (4) takes distances to water type canal 1 (gracht). Models (5) to (8) also use the same variables as both the base model (1) and models (2) to (4), but are tested separate for each type of property to test the robustness of the results. The equation for the baseline model (1) is estimated as follows:

$$\ln \mathrm{P}_{a,l} - \ln \mathrm{P}_{b,l} = \alpha + \sum_{k=1}^{K} \beta_k \left(\mathrm{X}_{a,k,l} - \mathrm{X}_{b,k,l} \right) + \sum_{m=1}^{M} \beta_l \left(A_{a,m,l} - A_{b,m,l} \right) + \varepsilon_{\mathrm{a,b,l}} \quad (1)$$

where $\ln P_{a,l}$ and $\ln P_{b,l}$ are the natural logarithms of paired transaction price of house a and b; α is the constant; $X_{a,k}$ and $X_{b,k}$ contain the house characteristics (k = 1, …, K), year of transaction being 2019; $A_{a,m,l}$ and $A_{b,m,l}$ are dummy variable vectors that measure the distance to nearest body of water; l indexes postal code-4 areas in which a and b are paired and $\varepsilon_{a,b,l}$ is the error term. Mostly in line with Roosendaal (2017), the distance is measured in spatial intervals of 0-25m; 25-50m; 50-100m; 100-200m; 200-400m; and 400 and above. The houses are paired at postal code-4 level. For reproducibility among models the data is sorted based on sales date when grouped.

3. DATA

The main data required consists of data on water areas and on residential transactions. The residential transactions are retrieved from the registry of the Dutch Association for Real Estate

Agents (NVM) which, in 2019[2], had a market share of around 70% of all sold houses in the Netherlands (NVM, 2019). The transaction dataset includes different property characteristics such as transaction price and date, living area, number of rooms, lot size, year of construction, property type and in some cases the energy label. The used variables are selected on literature and number of missing cases (Visser et al,, 2006; Visser et al., 2008). For example, the majority of cases for energy label is not filled in, and therefore the variable is left out of the study. Cleaning the data consisted of removing double listings, and errors such as zero square meter property surface. Furthermore, transactions with missing cases for the used variables are deleted. Only transactions which are sold voluntary, so no auctions, are kept. Arguably, due to differences in property characteristics and their effects on price, apartments and single-family homes cannot be considered as one group. Since single-family homes has the largest amount of cases, this study only uses single-family home transactions. After cleaning the data, 187,547 transactions of residential properties across the Netherlands in 2019 remain.

The data on the variable of interest, proximity of water, is gathered using GIS-mapping. The map with water information is retrieved from the 'Basisregrestratie Grootschalige Topografie' (BGT), which is created by the Dutch government. The scale of the map is 1:5,000, resulting in accuracy up to 20 centimetres. The available types of water are: ditches ('greppel'), water courses, rivers, lakes, canals (both 'gracht' and 'kanaal'), harbour water, and the sea. For this study only freshwater bodies are selected, leaving out the sea and trenches/ditches. Important to note is that type canal 1 (gracht) is mostly situated in city centres, therefore possibly correlating with the amenities in the centres. Within city centres green or blue areas are often scarce, making it interesting to distinguish the price effects and study if this holds additional value compared to areas richer in natural areas, and for that reason are taken into the analysis. The locations from the transaction data are linked to the water locations using the 'near-analysis' in QGIS.

Since the data is gathered from secondary data sources, the ethical considerations of this research are limited. The data is treated confidentially, meaning that addresses and 'personal' information including *individual* transaction prices are excluded from the paper.

Table 1 depicts the summary statistics of the property characteristics and measured distances to nearest water used in the analysis. As can be seen, the furthest distance to nearest water is relatively short, being a little over 1 kilometer, whilst there are also properties that are

[2] The year 2019 is selected due to the supply and demand on the Dutch real estate market. Though 2019 was already an up-moving market, since 2020 the Dutch real estate market is increasingly seen as overheated. For example, 2021 had price increases of over 17% compared to the year before (Parool, 2021).

adjacent to a body of water. The single-home transaction prices range between € 115,000 and € 955,000. The bottom and top 1% of transaction price are deleted to increase the model fit, as is common in the literature (Daams et al., 2019). The average transaction price for single-family homes in 2019 in the dataset is € 338,127 which is fairly in line with the € 309,000 national average in 2019 measured by the Dutch Central Bureau for Statistics (CBS, 2021). The CBS also includes apartments, which in general are of lower value than single-family homes, and in turn lowers the average. The average floor space is 127 m² and the average parcel size is 280 m². The average number of rooms is 5, where the smallest property has 1 room and the largest 15. Buyers condition is a dummy for buyers costs (0) or free in name (1). Free in name is a measure for newly constructed properties, with newly constructed properties the buyers costs are for the seller instead of the buyer. The properties types are categorized in four types: terraced houses, corner houses, semidetached houses and detached houses. The building periods are categorized, using Middelkoop's (2014) study for Dutch governmental research which divides building periods into six types.

Table 1: Descriptive statistics

Variable	Mean	St. Dev.	Min	Max
Price (euros)	338,126.50	112,889.50	115,000.00	955,000.00
Floor space (m²)	127.09	36.84	36.00	490.00
Parcel size (m²)	279.60	674.46	18.00	51,730.00
Number of rooms	5.04	1.22	1.00	15.00
Buyers condition (buyers cost 0 or free in name 1)	0.92	0.27		
Property type - Terraced house (1 = yes)	0.47	0.50		
Property type - Corner house (1 = yes)	0.18	0.38		
Property type - Semidetached house (= yes)	0.21	0.41		
Property type - Detached house (1 = yes)	0.14	0.35		
Building period - 1945 and before (1 = yes)	0.18	0.38		
Building period - 1946-1965 (1 = yes)	0.12	0.33		
Building period - 1966-1974 (1 = yes)	0.13	0.33		
Building period - 1975-1991 (1 = yes)	0.23	0.42		
Building period - 1992-2005 (1 = yes)	0.18	0.38		
Building period - 2006-2022 (1 = yes)	0.18	0.38		
Property distance to nearest water	113.83	114.53	0	1,064.69
Number of observations	187,547			

Note: the transaction year for all observations is 2019.

Table 2: Dispersion of property distance to water

Categorized properties distance to nearest water	Observations	Observations	Observations	Observations

	Total of water	Water course	Lake/pond	Canal 1
Category zero < 25m	32,942	12,211	1,507	631
Category one 25-50m	31,124	12,267	1,808	776
Category two 50-100m	48,939	18,664	3,493	1,398
Category three 100-200m	46,187	16,224	4,805	1,461
Category four 200-400m	23,055	6,563	3,823	487
Category five > 400m	6,300	1,197	1,617	28

The relationship between the dependent variable, natural logarithm of price and variable of interest, price and the distance to nearest is negatively correlated by 0.096 for model (1). Visualization of this relationship can be found in appendix C.

The properties distance to nearest water is categorized to study whether and how the effect behaves over different distances. The category range that had the best fit is 0-25m, 25-50m, 50-100m, 100-200m, 200-400m and 400 and above. The dispersion of the distances can be found in table 2. It shows that the majority of the analyzed Dutch properties are located relatively close by water. The dispersion per type of water can be found in appendix B.

The robustness of a possible effect is studied by differentiating the data for type of property. The property types in the dataset consist of terraced (46%), corner (17%), semi-detached (21%) and detached properties (16%). The dispersion of property types in the dataset are fairly consistent with the dispersion of the total Dutch housing stock as publiced by the Central Bureau for Statistics (terraced & corner being 50%, semi-detached 23% and 27% detached) (CBS, 2016).

4. RESULTS & DISCUSSION

This section reports the results of the Ps-RS analysis. The research aim is to discover whether water is valued economically and how this effect behaves over space. First, the results of the base model are discussed. After that, three models test the effect for largest three subtypes of water (in terms of number of cases). Finally, the robustness of the results is tested by differentiating for type of residential property. Different distances categories are used to study whether the effect of water changes spatially. The categories for the base model produce the best fitting model of multiple categories, both from literature and first-hand tests (Roosendaal, 2017). All other models use the same categories and variables as the base model, but do change for type of water or type of real estate.

Table 3 reports the results for the base model (1) which uses intervals for distance to nearest water, property characteristics and location fixed effects at postal code 4-level (N=

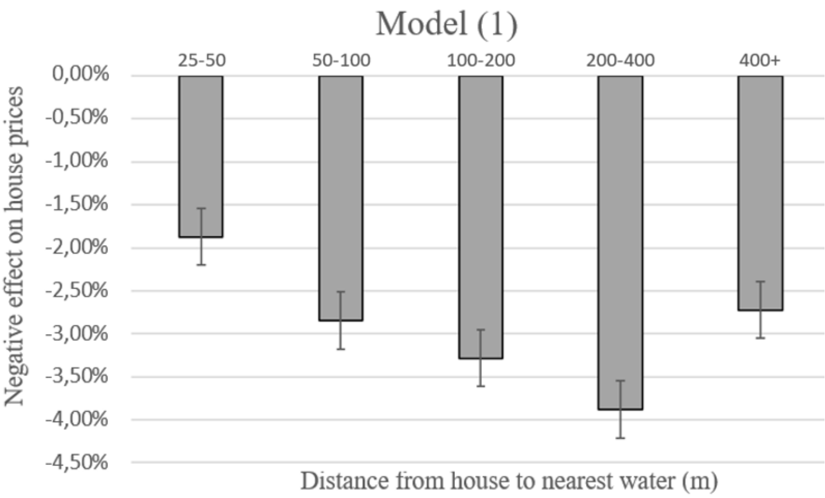
3,528) to control for location characteristics. As seen in the results for model (1), the distance to nearest water coefficients are all significant at the 1% level. Compared to the reference of 0-25m distance all other distances have a negative effect. More importantly, the negative effect seems to be increasing as distance grows. Meaning that the properties nearby water have an, on average, higher value than properties further away from water. The *negative* price effects for the distance categories are -1.91%, -2.93%, -3.40%, -4.04% and -2.80% (= (Exp^coeff −1) ×100), respectively, and on average. A visualization of this effect can be found in figure 1. The hypothesis that proximity to water can affect a properties price between 4% and 7% is barely made. The hypothesis considers earlier literature. Luttik (2000) found significant higher results for properties adjacent to water (up to 12%), which is not specified for this study. However, Luttik found similar results for properties nearby water (5%). The results are also similar to Rouwendal et al. (2017), who find a 4% to 6% premium for the properties closest to water. An important difference is that Rouwendal et al note that the effect of water decays after 60m, this study proves that the water affects a price for longer distances than previously thought. When taking a closer look the remaining independent variables, floor space, parcel size and type of property seem to be most influential for determining the price of a property. The buyers condition, whether it is free in name or buyers cost, is insignificant, thus no statements will be made regarding the effect. Compared to reference 2006 and later, most of the remaining building periods are negativeThis is in line with expectations, as newly build properties usually are 'up to today's standards', and therefore have a higher comfort or require less maintenance or renovations than older properties. The reference for type of property is detached properties.

Table 3: Ps-RS regression results for the base and specific types of water models

	(1)	(2)	(3)	(4)	(5)
	Base model 'all water'	Water course	Lake/pond	Canal 1	Pooled
Distance to nearest water (m) 25-50	-0.019*** (0.002)	-0.020*** (0.004)	-0.026*** (0.010)	-0.051*** (0.013)	-0.021*** (0.003)
Distance to nearest water (m) 50-100	-0.029*** (0.002)	-0.028*** (0.003)	-0.036*** (0.010)	-0.076*** (0.012)	-0.031*** (0.003)
Distance to nearest water (m) 100-200	-0.033*** (0.002)	-0.031*** (0.004)	-0.047*** (0.010)	-0.076*** (0.014)	-0.037*** (0.003)
Distance to nearest water (m) 200-400	-0.040*** (0.003)	-0.035*** (0.005)	-0.049*** (0.011)	-0.075*** (0.013)	-0.041*** (0.004)
Distance to nearest water (m) > 400	-0.028*** (0.006)	-0.040*** (0.008)	-0.020 (0.016)	-0.100*** (0.041)	-0.033*** (0.008)
Floor space (log)	0.565*** (0.007)	0.563*** (0.010)	0.537*** (0.019)	0.486*** (0.027)	0.564*** (0.009)
Parcel size (log)	0.144*** (0.004)	0.140*** (0.007)	0.177*** (0.012)	0.160*** (0.018)	0.142*** (0.006)
Number of rooms (log)	0.015*** (0.003)	0.008 (0.005)	0.001*** (0.010)	0.054*** (0.019)	0.008** (0.005)
Buyers condition - Free in name	-0.002 (0.006)	-0.019*** (0.009)	0.037* (0.021)	0.026 (0.028)	-0.010 (0.008)
Property type - Terraced house	-0.189*** (0.005)	-0.216*** (0.008)	-0.186*** (0.014)	-0.172*** (0.024)	-0.200*** (0.007)
Property type - Corner house	-0.176*** (0.004)	-0.197*** (0.007)	-0.172*** (0.011)	-0.165*** (0.021)	-0.182*** (0.006)
Property type - Semidetached house	-0.089*** (0.004)	-0.101*** (0.006)	-0.087*** (0.010)	-0.077*** (0.020)	-0.092*** (0.005)
Building period - min – 1945	-0.161*** (0.005)	-0.178*** (0.008)	-0.158*** (0.018)	-0.149*** (0.032)	-0.166*** (0.007)
Building period - 1946-1965	-0.186*** (0.005)	-0.196*** (0.007)	-0.195*** (0.016)	-0.189*** (0.029)	-0.187*** (0.006)

Building period - 1966-1974	-0.203*** (0.004)	-0.214*** (0.006)	-0.184*** (0.013)	-0.235*** (0.037)	-0.206*** (0.005)
Building period - 1975-1991	-0.144*** (0.004)	-0.153*** (0.005)	-0.136*** (0.013)	-0.147*** (0.021)	-0.146*** (0.005)
Building period - 1992-2005	-0.066*** (0.003)	-0.072*** (0.005)	-0.053*** (0.012)	-0.068*** (0.018)	-0.067*** (0.004)
Constant	0.008*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	-0.001*** (0.000)	0.001*** (0.000)
Location effects scale	ZIP4	ZIP4	ZIP4	ZIP4	ZIP4
Observations	184,024	65,088	16,028	4,654	92,640
R-squared	0.72	0.75	0.72	0.76	0.73

Note: All transactions are in 2019. The dependent variable is log difference of transaction price. The reference category for distance to water is 0-25m. The reference categories for dummy buyers condition is 0, being buyers cost. The reference category for property type is detached houses and for building period it is the year 2006 and above. All models include a constant term. Fixed effects for location are at postal code 4-level. Standard errors in parentheses with *** , **, * indicating significant at 1%, 5% and 10%, respectively.



Note: the confidence intervals are based on the 95% level. Reference category is 0-25m.

Figure 1: Visualization of the percental price effects for distance to water

To further analyse the effect of water on residential property prices multiple models are selected. Models (2) to (4) are selected on specific types of water, being water courses, lakes/ponds, and canal type 1 (gracht). Unfortunately, around 50% of the specific types of water retrieved from the BGT dataset are labelled ‘unknown’, which means they cannot be used for the watertype-specified models. To validate the reliability of the data which includes the ‘unknown’ types, a pooled model (5) is created. Model (5) is the same as model (1) but without the ‘unknown’ specific water types. The results of both models are similar, hinting that the ‘unknown’ water types do not alter the data drastically. The three analysed water-specific types are selected on number of observations and make use of the same variables and categories as the base model, but only takes the observations for that specific type of water. The size of the distance categories are based on the working of the full model, and are kept the same to be able to compare them with each other. The results show relatively strong differences between the models, hinting that different types of water are valued differently. Canal type 1 shows the highest price effects for distance to water. Canal type 1 possibly correlates with inner city functions or locational qualities, but as mentioned before, is left since it is an official type of water and remains interesting to study. The canal type 1 cases are scattered throughout different cities across the Netherlands. Some cases are also placed at the borders of a city, but having the same body of water as the water in the main city centre, thus still being canal type 1. Therefore, the effect of inner city correlations with canal type 1 seems relatively limited. The results for water courses are similar to the main model (1) whereas the results for lakes and ponds lie inbetween the results for water courses and canal type 1.

Important to note is that the observed negative effect on price still becomes larger as distances also becomes larger for all models. Meaning that proximity to water is valued positively throughout the different types of water. The individual size of the coefficients depends on the type of water. Water courses' coefficients are relatively small compared to type canal 1, and distance to lake/ponds lies only slightly higher than water courses. The variable buyers condition is often insignificant, but is left in due to institutional differences between buyers cost and free in name. The remaining variables remain fairly stable and consistent throughout the different models[3]. In short, the spatial effect of water on price is consistent throughout the models, as distance increases the negative price effect also increases. The discount for properties further away remains eminent, but the size does differ per type. Hinting that different types of water are valued differently. This is possibly due to different possible uses on different types of water. For example, lakes and ponds are valued slightly higher than water courses. This may be due to additional (recreational) uses lakes and ponds may have, such as the possibility to go boating or swimming.

By finding a difference between types of water, the second hypothesis has failed. The second hypothesis, mostly based on earlier literature by Rouwendal et al. (2017) stated that there would not be difference in the valuation of distance to water between the types of water. Rouwendal et al. (2017) concluded that they found no difference in the effect of distance to water on price for different types of water. Whereas student thesis by Roosendaal (2017) did find a difference between types of water. As mentioned before, previous (international) literature is mixed regarding this subject. Though local differences are possible, this study sets new evidence that there is a difference between the valuation of types of water.

Table 4: Ps-RS regression results for different types of properties

[3] A detached property and newly constructed property remain the most dominant among their categories, as compared to those the remaining categories are negative. Floor space and parcel size remain having the strong price effects.

	(6) Terraced	(7) Corner	(8) Duplex	(9) Detached
Distance to nearest water (m) 25-50	-0.020*** (0.003)	-0.011*** (0.004)	-0.020*** (0.004)	-0.027*** (0.007)
Distance to nearest water (m) 50-100	-0.033*** (0.003)	-0.024*** (0.004)	-0.023*** (0.004)	-0.043*** (0.007)
Distance to nearest water (m) 100-200	-0.039*** (0.003)	-0.025*** (0.005)	-0.028*** (0.004)	-0.052*** (0.009)
Distance to nearest water (m) 200-400	-0.046*** (0.004)	-0.027*** (0.006)	-0.038*** (0.006)	-0.064*** (0.011)
Distance to nearest water (m) > 400	-0.027*** (0.009)	-0.028** (0.012)	-0.036*** (0.009)	-0.039** (0.020)
Floor space (log)	0.546*** (0.008)	0.542*** (0.010)	0.515*** (0.009)	0.623*** (0.015)
Parcel size (log)	0.177*** (0.005)	0.174*** (0.005)	0.189*** (0.005)	0.094*** (0.007)
Number of rooms (log)	0.015*** (0.005)	0.028*** (0.007)	0.029*** (0.006)	0.019* (0.010)
Buyers condition - free in name	0.000 (0.009)	-0.007 (0.010)	-0.018** (0.008)	-0.014 (0.023)
Building period - min – 1945	-0.141*** (0.007)	-0.162*** (0.010)	-0.215*** (0.007)	-0.185*** (0.012)
Building period - 1946 - 1965	-0.214*** (0.005)	-0.219*** (0.007)	-0.228*** (0.007)	-0.140*** (0.013)
Building period - 1966 - 1974	-0.227*** (0.004)	-0.241*** (0.007)	-0.215*** (0.006)	-0.136*** (0.012)
Building period - 1975 - 1991	-0.163*** (0.004)	-0.182*** (0.006)	-0.154*** (0.005)	-0.103*** (0.011)
Building period - 1992 – 2005	-0.074*** (0.004)	-0.084*** (0.006)	-0.077*** (0.005)	-0.064*** (0.009)
Constant	0.003*** (0.000)	0.003*** (0.000)	0.002*** (0.000)	0.007*** (0.000)
Location effects scale	ZIP4	ZIP4	ZIP4	ZIP4
Observations	85.065	30.812	36.698	23.980
R-squared	0.63	0.65	0.66	0.59

Note: All transactions are in 2019. The dependent variable is log difference of transaction price. The reference category for distance to water is 0-25m. The reference categories for dummy buyers condition is 0, being buyers cost. The reference category for building period is the year 2006 and above. All models include a constant term. Fixed effects for location are at postal code 4-level. Standard errors in parentheses with *** , **, * indicating significant at 1%, 5% and 10%, respectively.

Table 4 presents the results for the base model, so with nearest distance to general type of water, when ran separate per type of property for robustness. The coefficients again show a steady decrease in price as distance from water grows. The results for terraced, corner and duplex houses are relatively stable and similar to the base model (1)[4]. The negative effect for detached houses is strongest, being -2.74%, -4.39%, -5.34%, -6.61% and -3.98% from nearest to furthest, respectively. The effect is lowest for corner houses. Also for models (6) to (9) the spatial effect is consistent throughout the models, as distance increases the negative price effect also increases. And again, the discount for properties further away remains eminent, but the size does differ per type.

6. CONCLUSION

Water is associated with positive values, such as recreational or aesthetic pleasure and health benefits, but also has downsides such as risk of flooding. Due to increasing urbanization, climate change, and changes in the use of water, the valuation of it has increasingly become

[4] When looking at the remaining variables the effect of floor space is relatively stable across the models. The buyers condition shows insignificant results, as is seen in the previous models (1) to (4). The building period 2006 and above remains strongest for the building periods, as compared to that all other coefficients are negative. Even though the some of the coefficients differ from the base model, most of them remain relatively stable and show consistent results.

more important in order for future generations to enjoy the benefits, or asses the risks of it. To study whether water holds economic value, residential property transactions are used. In total 187,547 transactions in 2019 throughout the Netherlands are used. The distances of the properties to nearest type of water are retrieved using a governmental dataset on water and Geographical Information Systems. To capture an effect this study makes use of the pseudo-repeat sales model, where location effects are grouped at postal code 4-level. The properties distance to water does affect the sales price. When compared to properties nearby water (<25m), a negative effect can be seen. The larger the distance, the larger the discount in transaction price. This negative effect starts at -1.91% for distances between 25 and 50 meters, and steadily increases up to -4.04% for distances between 200 and 400 metres, on average. After 400 metres the coefficient is -2.80%. As for specific type of water, this seems to affect the price-effect. Canal type 1 seems to have a relatively strong effect, possibly due to correlation, whilst the effects of water courses and lakes are similar and limited. The differentiated results for type of property seems to be more robust, meaning that the effects are fairly similar for all types of properties. There is no sign that there is discount for a fear of possible flooding in the Netherlands, on average, the benefits of living nearby water seem to outweigh this possible risk. These results are reasonably in line with earlier literature, except that the effect of distance to water on transaction price carries on further spatially than previously considered.

The findings of this study can be of use for policy makers. As mentioned earlier, the majority of the properties in the Netherlands are situated nearby water. Therefore, policy makers' decisions regarding water possible affect a large part of the population. Since the effect spatially carries on further than previously considered, this brings increased added value to bodies of water, since more Policy makers can use these indirect capitalized values in their cost-benefit analysis when dealing with water management and for land use planning. The maximization of the well-being of residents through enjoyment of the benefits from water can now be estimated more precisely. In addition to policy makers, real estate developers can also benefit from the insights. Developing with water brings a premium for the to be developed properties, thus having *possible* added value for marketability and profitability of a project. The study also adds to the literature, since the valuation of water in the Netherlands has been a relatively overlooked compared to other amenities. Complementary to the existing literature this study is able to capitalize the effect on a larger scale. Though not being completely comparable, this studies' results are in line with the existing literature in a sentence that water does hold value for homeowners.

As with most studies, this study also comes with its limitations. The missing values for specific types of water can be seen as a potential improvement. For the robustness analysis, which makes use of the specific types, results could improve when all unknown types would be known. Secondly, as some of the literature notes, water quality is also of influence for its valuation. Initially, this study wanted to include water quality to the dataset. However, the Dutch government uses a 1-strike-out policy when scoring the quality of water. Meaning that when given scores on biological, ecological and chemical measurements the lowest score is published, resulting in a ‘poor’ or ‘insufficient’ rank for the majority of Dutch waters. If data on individual ranks of biological, ecological or chemical would become public, this would enlarge the potential to use it in further research. Another addition for further research would be to differentiate the attractiveness of the types of water. For example, whether a lake that allows for watersports valued is higher than a lake on which it is not allowed.

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APPENDIX

Appendix A. Glossary

Variable:	Definition:
Distance to water	The distance from a properties to nearest piece of water. Original measurement is meters.
Floor space	The livable surface of a property. Original measurement is in square meters.
Parcel size	The size of the property. Original measurement is in square meters.
Number of rooms	The amount of rooms within the properties.
Buyers condition	Whether a property is newly build it's buyer condition is 'free in name' (in dutch 'Vrij Op Naam'), meaning that the buyer has no additional costs. When the buyers condition is buyers cost, the costs required to purchase a property, such as transfer tax and notary costs are to be paid by the buyer.
Property type	The type of property. For this study the considered types are detached, semi detached, corner and terracced houses.
Building period	The period in which the property is constructed.

Appendix B. Tables

Table 1: Specific types of water and the number of their observations

Type of water	Number of observations
Water course (sloot)	67,126
Lake or pond	17,053
Canal 1 (gracht)	4,781
Canal 2 (kanaal)	3,089
River	1,145
Harbour	826
Other (creek, spring)	991
Unknown	92,511
Total	187,547

Table 2: Model behavior when adding water variables and location effects

	(10) Without water Without location	(11) With water Without location	(12) Without water With location
Floor space (log)	0.885*** (0.003)	0.878*** (0.003)	0.567*** (0.007)
Parcel size (log)	0.009*** (0.002)	0.005*** (0.002)	0.147*** (0.004)
Number of rooms (log)	-0.012*** (0.003)	-0.005 (0.003)	0.014*** (0.003)
Buyers condition - free in name	-0.039*** (0.003)	-0.042*** (0.003)	-0.000 (0.006)
Property type - Terraced house	-0.091*** (0.003)	-0.085*** (0.003)	-0.191*** (0.005)
Property type - Corner house	-0.063*** (0.003)	-0.057*** (0.003)	-0.179*** (0.004)
Property type - Semidetached house	-0.048*** (0.002)	-0.041*** (0.002)	-0.091*** (0.004)
Building period - min - 1945	-0.033*** (0.003)	-0.018*** (0.003)	-0.165*** (0.005)
Building period - 1946-1965	-0.139*** (0.003)	-0.119*** (0.003)	-0.191*** (0.005)
Building period - 1966-1974	-0.251*** (0.003)	-0.232*** (0.003)	-0.208*** (0.004)
Building period - 1975-1991	-0.179*** (0.003)	-0.169*** (0.003)	-0.147*** (0.004)
Building period - 1992-2005	-0.077*** (0.003)	-0.073*** (0.003)	-0.067*** (0.004)
Distance to nearest water (m) 25-50		-0.048*** (0.002)	
Distance to nearest water (m) 50-100		-0.069*** (0.002)	
Distance to nearest water (m) 100-200		-0.091*** (0.002)	
Distance to nearest water (m) 200-400		-0.109*** (0.003)	
Distance to nearest water (m) > 400		-0.015*** (0.004)	
Constant	8.420*** (0.000)	8.636*** (0.015)	
Location effects scale	none	none	ZIP4
Observations	187,547	187,547	184,024
R-squared	0.48	0.49	0.71

Note: All transactions are in 2019. The dependent variable is log difference of transaction price. The reference category for distance to water is 0-25m. The reference categories for dummy buyers condition is 0, being buyers cost. The reference category for property type is detached houses and for building period it is the year 2006 and above. All models include a constant term. Fixed effects for location are at postal code 4-level. Standard errors in parentheses with *** , **, * indicating significant at 1%, 5% and 10%, respectively.

Appendix C. Graphs

The graph below displays the scatterplot that visualizes the relationship between a properties distance to water and the properties price. Studying this graph helps to understand the association between said variables. In the figure below, the vertical axis shows the transaction price, and the horizontal axis shows the properties distance to nearest water. The black triangles denote the cases and the grey-blue line represents the fitted values. In general, the further away a property is from water, the lower the price.

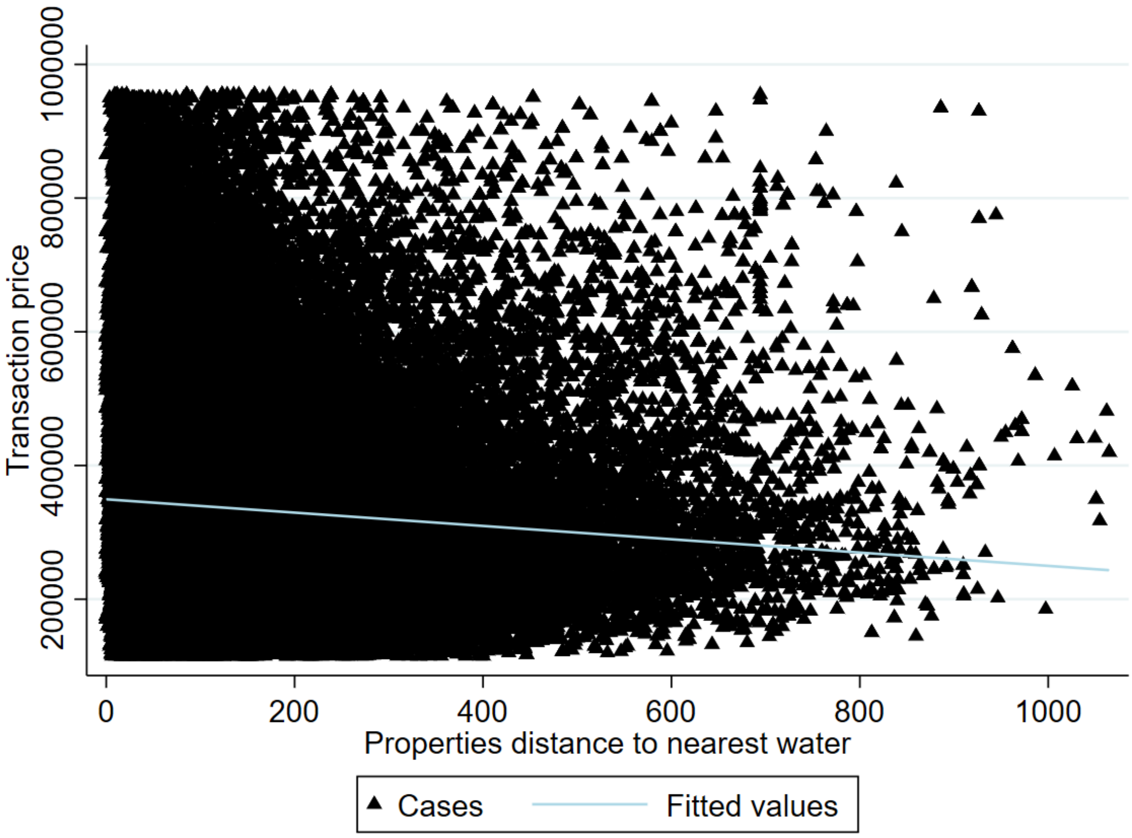

Figure 1: the relationship between transaction price and distance to nearest water.