university of groningen

Bachelor thesis

Mean Sea Level and Average House Price: Evidence from twenty coastal oriented municipalities in the Netherlands

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Date: 17-12-2017

Abstract:

The sea level along the Dutch coast has risen with about 23 cm in 125 years. Currently half of the country is below sea level and is therefore permanently threatened by flooding, if there would be no protection. Besides, the most of the population and economic activity of the Netherlands are concentrated in the low lying coastal municipalities. This paper attempts whether the changing sea levels from 1995-2016 had an effect on the value of residential properties on twenty coastal oriented municipalities. Which geographically represents the whole Dutch coastline with regional differences in economic development. It explores the developments of the variables in time using fixed effects (FE) panel regression analysis. This paper fills a gap in the literature, because there is no other literature to the authors knowledge that has done this research with existing sea level data using panel data analysis, especially not for the Netherlands. Moreover, while comprehending sea level rise from scientific point of view is crucial, it is also necessary to incorporate economic assessment into decision making. In the first FE panel regression model without control variables the mean sea level is positively associated with the average house price and is significant. A sea level rise of one millimeter increases the average house price with 830 euro. This is against the hypotheses that sea level rise produce a negative impact on coastal house prices. In the second FE panel regression model with control variables the mean sea level is negatively associated with the average house price, but is insignificant. Notable is that the model fit is increased from 22% in the first model to 68% in the second model, which makes the second model considerably stronger than the first one. Therefore this paper concludes that there is no effect between changing mean sea levels and house price development on coastal real estate on the basis of the obtained dataset.

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1. Introduction

The pressure of sea level rise has increased since the last century and is therefore one of the major concerns the Dutch have to deal with. The sea level along the Dutch coast has risen with about 23 cm in 125 years (see appendix figure 1). Converted that is a sea level change of 1.9 mm per year. This largely corresponds the global rise of the sea level of about 22 cm over the same period (Rijksoverheid, 2016). In all the scenarios investigated for the next century the rate of sea level rise will only be higher. This acceleration has to a large extent to do with the warming of the ocean and the increase of mass loss of glaciers and ice caps (KNMI & PBL, 2015).

Some of the most economic developed areas in the Netherlands are located in the low lying coastal municipalities[1]. Furthermore, the most of the population of the Netherlands are concentrated around these coastal municipalities. Currently about half of the country is below sea level (see appendix figure 2) and is therefore permanently threatened by flooding, if there would be no protection (Bernardi et al., 2008; Koningsveld et al., 2008). Mainly due to economic benefits and strong preferences for living nearby water coastal municipalities are facing a growth in their population and in their property prices. Hence, these dense and valuable municipalities are more vulnerable for flood risks partly due to sea level rise[2]. Thus, a major flood would be catastrophic and has a huge impact for the coastline (Bin et al., 2010).

Attention need to be paid for the water management of the Netherlands. In order to protect the country against floods there are defense mechanisms such as dikes, dunes and other hydraulic structures. The country is divided in dike ring areas. For each dike ring area there are certain safety standards laid down in the Flood Protection Act of 1996 invented by the Delta commission depending on the economic value of that area (Bernardi et al., 2008).

This paper attempts whether the sea level from the last decades had an effect on the value of residential properties on twenty coastal oriented municipalities. Which geographically represents the whole Dutch coastline with regional differences in economic development.

In the scientific literature there are many studies that examine the effect of a natural hazard on property prices. For example, Frederick & Yoo (2017) investigated whether soil subsidence and earth fissures had an impact on housing values using a quantile regression and Zhang et al. (2010) evaluated the effects of natural hazards on property values by using a hedonic price regression.

There are also many researchers that had their focus on the impact of flood hazards on property prices in the United States. The results of most of these studies showed us that there is a negative impact of flood hazards on house prices. In other words, a house that is located within a floodplain area has a lower market value than a similar house that is not located in a floodplain area. (Bin & Polasky, 2004; Zhang, 2016). These results imply the perception of flood risk and the discount associated with living in uncertain areas for flood threat. Yet, other studies find contradictory results where there is no significant effect (Muckleston, 1983) or where there is even a positive effect (Montz, 1993). This suggest that positive amenities from living nearby a coastline outweighs the risk of flooding. Next to the effect on property prices, most published work additionally addresses whether the US

[1] Two (Amsterdam and Rotterdam) out of ten cities worldwide with the largest amount of capital in low lying areas lie in the Netherlands.

[2] Also partly due to soil subsidence that occurs in areas as a result of groundwater extraction and soil declining (Frederick & Yoo, 2017). This will not be the focus of this study. To improve further understanding, future research may add this variable.

National Flood Insurance Program (NFIP) is effective or not. This program ensures that future flood damage can be insured by property owners (Meldrum, 2015; Zhang, 2016).

There is a limited amount of literature in other countries that studied the effect of flood hazards on property prices, including the Netherlands. By focusing on the municipalities near the Meuse high tide events in 1993 and 1995, Daniel et al. (2009) found that the total impact on property prices affected is 9.1 per cent using a hedonic price method. Besides that, they also found that water has positive effects on property prices, because water is a source of positive amenities. This corresponds with the theory that almost all environmental features generally associated with positive amenities also raises the risk of natural hazards, such as coastlines with flooding (Bin & Polasky, 2004).

Little is known about the impact of the rising sea level on house prices, which eventually enhance the risks of flooding on coastal real estate. Some researchers estimated the potential costs of the rising sea level on coastal real estate, by analyzing hedonic prediction models. Fu et al. (2016) estimated that a 3-foot sea level rise in 2050 could cost the real estate market of Hillsborough and Pinellas County in Florida respectively over 300 and 900 million dollar. Bin et al. (2010) estimated that the cost for coastal real estate of four counties in North Carolina with a mid-range sea level rise are 179 million dollar in 2030. Most of the other existing literature about sea level rise deals with the causes of the rising sea level as a process of climate change often due to human contribution (Jevrejeva et al., 2009). Several recent studies examine the consequences of the rising sea level for the future. When focusing on the Netherlands, a lot of attention is paid to the water management planning, including protection and adaptation for the purpose of future policy making (Kwadijk et al., 2010).

The main novel of the existing literature are using prediction models with different scenarios for sea level rise to estimate future potential costs on coastal real estate. Since the rising sea level is going on for decades, this paper is using the most recent existing sea level data to give insight in the effect of the changing sea level on residential house prices in twenty coastal oriented municipalities in the Netherlands from 1995-2016. It explores the developments of the variables in time using fixed effects panel regression analysis. Panel data contain observations of multiple phenomena obtained over multiple time periods for the same group of individuals. This paper fills a gap in the literature, because there is no other literature to the authors knowledge that has done this research with existing sea level data using panel data analysis, especially not for the Netherlands. Moreover, while comprehending sea level rise from scientific point of view is crucial, it is also necessary to incorporate economic assessment into decision making.

The remainder of the thesis is organized as follows. The next section describes the selection of the data and time span. The variables which may influence the average house price will be discussed. After the composition of the variables, the methodology of the analysis will be explained. Section 3 summarizes the main findings of this paper and discuss these findings with earlier research. The last section present the conclusion and the recommendations for further research.

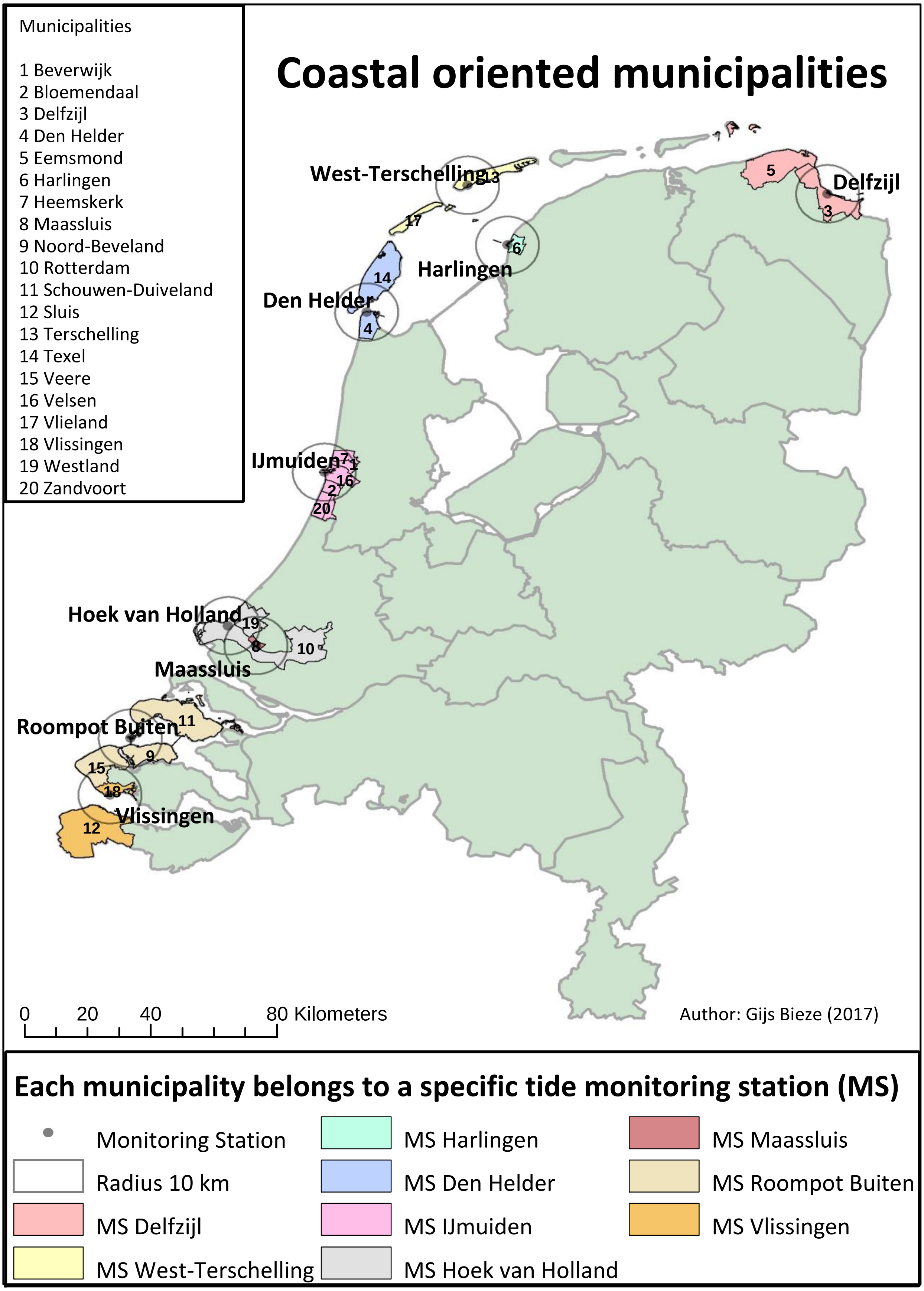

Figure 1: Overview of the tide monitoring stations and the selected coastal oriented municipalities. Source: Gijs Bieze (2017).

2. Data

The analysis was performed with the yearly data from twenty coastal oriented municipalities and nine tide monitoring stations in the Netherlands (see figure 3). There are 34 coastal oriented municipalities in the Netherlands defined by KIMO (2017). Only the coastal oriented municipalities that are located within a radius of ten kilometers from a tide monitoring station are used in the data to optimize the quality. If it would be further than ten kilometers, the mean sea levels could differ too much with the original location of the tide monitoring station.

The time span of the dataset is from 1995 until 2016 in order to obtain the largest and most recent possible dataset for analysis that is available by the CBS, because before 1995 the requested residential house prices are unknown. This results in a cross sectional data set of twenty municipalities over a time span of twenty-two years, which adds up to 440 observations. The first issue that arose is that there are nineteen missing cases, because three municipalities are exceptions and have a different time span, namely Westland (2004-2016), Schouwen-Duivenland (1997-2016) and Sluis (2003-2016). This may be the cause of new created municipalities or merged municipalities by the national government. Hence, most of the municipalities have comparable timespans as can be seen in table 1.

Table 1. Time span selected municipalities

Tide monitoring station	Municipality	Time span
1. Delfzijl	3. Delfzijl	1995-2016
	5. Eemsmond	1995-2016
2. West-Terschelling	13. Terschelling	1995-2016
	17. Vlieland	1995-2016
3. Harlingen	6. Harlingen	1995-2016
4. Den Helder	4. Den Helder	1995-2016
	14. Texel	1995-2016
5. IJmuiden	1. Beverwijk	1995-2016
	2. Bloemendaal	1995-2016
	7. Heemskerk	1995-2016
	16. Velsen	1995-2016
	20. Zandvoort	1995-2016
6. Hoek van Holland	10. Rotterdam	1995-2016
	19. Westland	2004-2016
7. Maassluis	8. Maassluis	1995-2016
8. Roompot Buiten	9. Noord-Beveland	1995-2016
	11. Schouwen-Duiveland	1997-2016
	15. Veere	1995-2016
9. Vlissingen	12. Sluis	2003-2016
	18. Vlissingen	1995-2016

Each observation contains information about the dependent average house price variable (AHP) and about other variables that relate to the average house price (see table 2).

The first variable to include in the analysis is the mean sea level (MSL), because this study examines whether changing sea levels have an effect on residential house prices. The hypothesis of this paper is that sea level rise is expected to produce a negative impact on the house price development, because due to sea level rise there is more uncertainty of flooding and the perceived flooding risk. This corresponds with the findings of most of the existing literature about flooding risks and the effect on real estate (Bin & Polasky, 2004; Zhang, 2016). Although, taking the Dutch flood protection into consideration the house prices in coastal municipalities expected to be little affected by sea level rise.

Second, one macroeconomic determinant that influence the house price development is economic growth. The demand for space will increase as a result of economic growth. Since the housing stock cannot change in the short-run this will lead to higher house prices (Adams & Füss, 2010). One determinant that is strongly positively related to changes in house prices is the GDP per capita (Égert & Mihaljek, 2007). In this research the index of the GDP will be used to measure economic growth in relation to the house price development. The second issue that arose is that there might be regional differences in development of the GDP per capita between municipalities, but the GDP per capita per municipality was not available by the CBS. Therefore the variable gross domestic product index (GDPI) will be included in the estimation and the assumption here is that this is for every municipality the same.

Third, the model takes inflation into account as another macroeconomic determinant. Demary (2010) finds that changes in consumption are correlated with changes in house prices. One of the main conclusions is that inflation decrease house prices. For this reason this paper is using the consumer price index (CPI) as a variable and again is for every municipality the same.

At last, the demographic variable population (POP) is used, because a change in the population can cause a difference in the demand for space. An increase in the population would lead to a higher demand for space and therefore lead to higher house prices (Adams & Füss, 2010). Besides that, an extra variable will probably make the model fit (R-square) of a model stronger and so the estimation.

The variables used for the analysis are obtained from two different independent sources, namely Centraal Bureau Statistiek (CBS) and Permanent Service for Mean Sea Level (PSMSL). CBS is the national statistical office which provides reliable and coherent statistical information to the necessity of society. PSMSL is based in Liverpool and their main object is to gather and analyze sea level data from all the tide monitoring stations in the world.

Table 2. An overview of the data

Variables	Description	Source	Relation to AHP
Average house price (AHP)	Average residential house prices in euro (€)	CBS (2017)	
Mean sea level (MSL)	Mean sea level in millimeter (mm)	PSMSL (2017)	-
Population (POP)	Total population (real number) of a municipality	CBS (2017)	+
Gross domestic product index (GDPI)	Index of the gross domestic product (1995 = 100)	CBS (2017)	+
Consumer price index (CPI)	Inflation rate (1995 = 100)	CBS (2017)	-

A panel regression analysis will be used to estimate the effect of the mean sea level on the average house price development. The panel regression will be performed using panel data. Panel data contain observations of multiple phenomena obtained over multiple time periods for the same group of individuals. This study is using the fixed effects (FE) model, since this paper is only interested in analyzing the impact of variables that vary over time. Fixed effects explores the relation between independent and dependent variables within an entity. Each entity has its own individual characteristics that may or may not influence the dependent variable. In this paper the dependent variable is the average house price (AHP), explained by the variable of interest, the mean sea level (MSL), and three related control variables (population (POP), gross domestic product index (GDPI), consumer price index (CPI)) that are selected on the basis of prior literature. The dataset is large enough for the analysis even though the residuals might not have a normal distribution.

3. Results

Firstly in this section the data of the average house price and the mean sea level data in the selected municipalities are described. In almost all the municipalities the average house price increases over time fairly linearly with stagnation or a small decrease for roughly the time period of 2008-2013. This will be the cause of the financial crisis when there was a collapse of the real estate market. The exceptions from a linear pattern are Bloemendaal and Vlieland with some irregular fluctuations.

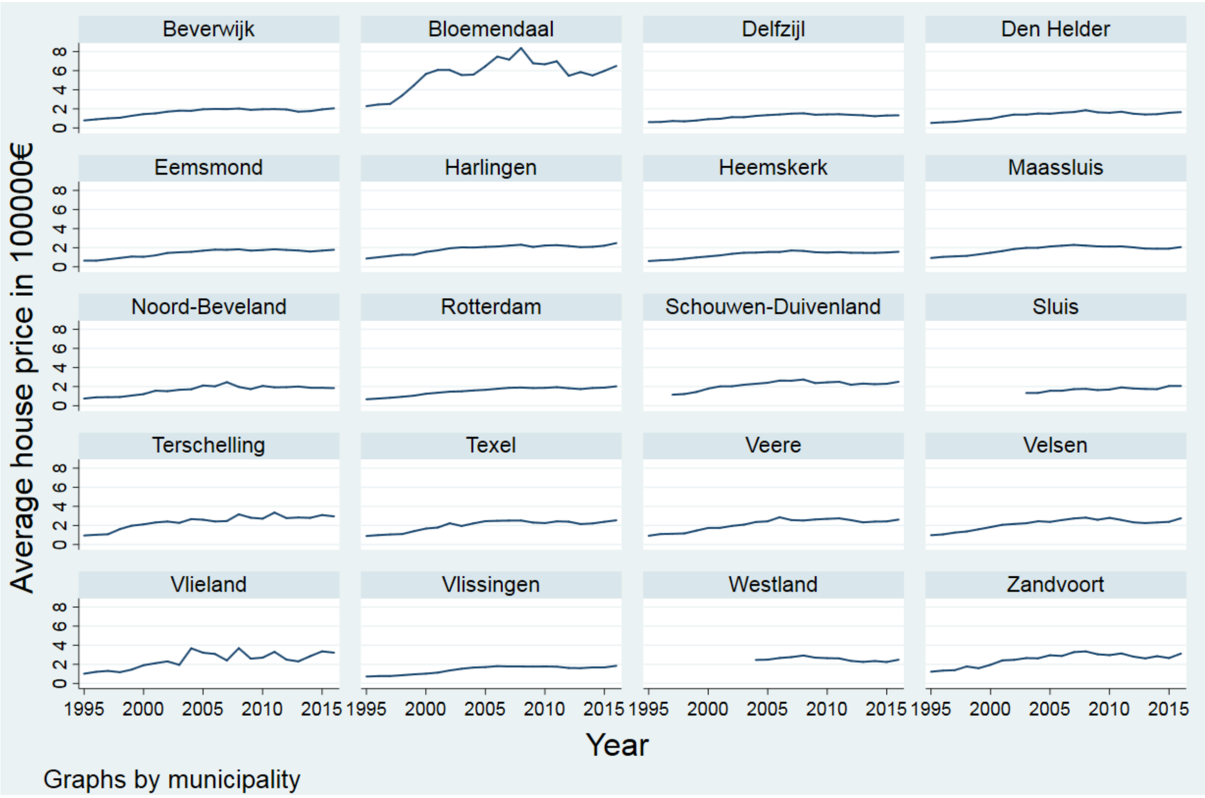

Figure 4: Average house price in selected municipalities 1995-2016. Source: Gijs Bieze, 2018

The patterns of the mean sea level are very similar for each municipality with one trough in 1996 and one peak in 2007. Overall there has been a little increase in the mean sea level over time. The municipalities Delfzijl, Eemsmond and Harlingen are having the most extreme fluctuations in their mean sea level pattern. The patterns of the mean sea level are not very similar to the patterns of the average house price. This indicates that there is no reason to think there is a relation between these variables on first sight.

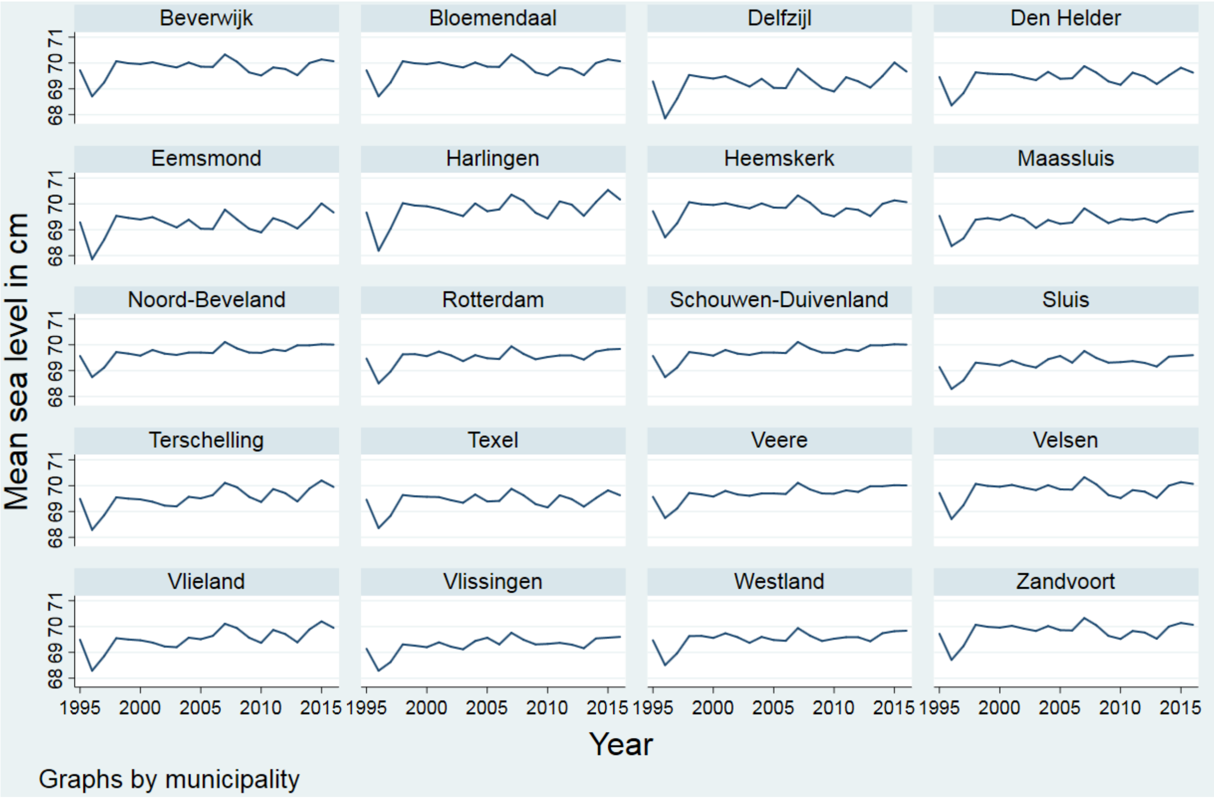

Figure 5: Mean sea level in selected municipalities 1995-2016. Source: Gijs Bieze, 2018

Secondly, a Hausman test is performed to decide if the appropriate model for the dataset of this study is indeed one with fixed effects rather than one with random effects. The null hypothesis is that the appropriate model is random effects (RE) and the alternative model is fixed effects (FE). The outcome is that prob>chi2 = 0.001. This means that the null hypothesis can be rejected and so the fixed effects (FE) model is accepted.

Thirdly, the panel regression model (FE) is performed between the dependent variable average house price (AHP) and the independent variable mean sea level (MSL) as can be seen in table 3. The prob>F of the model is significant at a 5 per cent level, which means that al coefficients are not equal to zero. Therefore the model can be used for analysis.

Table 3. FE model test results of the average house price – mean sea level regressions.

		ß-Coefficient	**Std. Error**	**P-value**
Average House Price (AHP)	**MSL**	829.5646	77.47883	0.000***
	Prob>F	0.0000***		
	R-square (FE)	0.2228		

*Note: ***p<0.01.*

In the fixed effects model the mean sea level is positively associated with the average house price and is significant. A sea level rise of one millimeter increases the average house price with 830 euro. This result is against the hypothesis that sea level rise is negatively related to the average house price. The model fit (R-square) is 0.2228 which means that only 22% of the variance of the average house price is explained by the mean sea level. The model fit could be better by adding up more control variables to the regression.

Finally, the panel regression model (FE) is performed between the dependent variable average house price (AHP) and the independent variable mean sea level (MSL) with three control variables as can be seen in table 4. Again, the prob>F of the model is significant at a 5 per cent level so the model can be used for analysis.

Table 4. FE model test results of the average house price – mean sea level regressions with three control variables.

		ß-Coefficient	**Std. Error**	**P-value**
Average House Price (AHP)	**MSL**	-87.45606	63.96353	0.172
	POP	0.4504136	0.5270389	0.393
	GDPI	5792.984	433.8307	0.000***
	CPI	-2016.642	359.0599	0.000***
	Prob>F	0.0000***		
	R-square (FE)	0.6788		

*Note: ***p<0.01.*

As can be seen in the fixed effects model with control variables the mean sea level is now negatively associated with the average house price. Looking at our hypothesis that sea level rise will produce a negative impact on the house price development this result appears to be a better outcome and so the model, although it is not significant (P>0.05). If the result was significant a sea level rise of one millimeter decreases the average house price with 87 euro. Another result is that the total population of a municipality (POP) is not related to the average house price in this model, because it is insignificant. Nevertheless it shows us the positive direction that was expected on the basis of previous research. The gross domestic product index (GDPI) and the consumer price index (CPI) are both significant (P<0.01). With 99% certainty this paper can conclude that an increase of 1% of the gross domestic product index increases the average house price on coastal real estate with 5793 euro and an increase of 1% of the consumer price index decreases the average house price on coastal real estate with 2017 euro. These significant variables also shown us the expected directions based on prior literature. Notable is that by adding up the control variables the model fit (R-square) has increased to 68% which indicates that the model is stronger than without the control variables.

4. Conclusion and discussion

This paper attempts whether the sea level from the last decades had an effect on the value of residential properties on twenty coastal oriented municipalities. Which geographically represents the whole Dutch coastline with regional differences in economic development.

The results of most of the existing literature showed us that there is a negative impact of flood hazards on house prices (Bin & Polasky, 2004; Zhang, 2016). Since sea level rise enhance the risk of flooding the hypothesis of this study is that the mean sea level produce a negative impact on the average house prices of coastal real estate. In the first FE panel regression model without control variables the mean sea level is positively associated with the average house price and is significant. A sea level rise of one millimeter increases the average house price with 830 euro. This corresponds largely with Montz (1993) findings, where a house that is located within a floodplain area has a higher market value than a similar house that is not located in a floodplain area. This suggest that positive amenities from living nearby a coastline outweighs the uncertainty of flooding and the perceived flooding risk due to sea level rise. In the second FE panel regression model with control variables the direction of all the variables are corresponding with the expected outcome. The gross domestic product index and the total population of a municipality are positively associated with the mean sea level, but only the gross domestic product index (GDPI) is significant. If the variable GDPI, the determinant for economic growth increase with one per cent the average house price of coastal real estate increases with 5793 euro. This outcome supports the theory of Égert & Mihaljek (2007) where economic growth leads to higher house prices, since there is a higher demand for space and the stock of the real estate market cannot change in the short-run. However, as told before this variable is for every municipality the same which is certainly not the case in real life, because there are regional differences in economic development. This makes the outcome more doubtful. The mean sea level and consumer price index are negatively associated with the average house price. The outcome of the consumer price index, the determinant for inflation, is significant concluding that an one per cent increase of the consumer price index decreases the average house price of coastal real estate with 2017 euro. This corresponds with one of the main conclusion of Demary (2010) where inflation decreases the average house price.

Notable is that the model fit is increased from 22% in the first model to 68% in the second model, which makes the second model considerably stronger than the first one. The p-value of the mean sea level in the second model is not significant (P>0.05) and therefore this paper concludes that there is no effect of changing sea levels on the average house price of coastal real estate on the basis of the obtained dataset.

There are some limitations to this paper. First of all, there is a limited amount of municipality-specific variables that were available by the CBS that had a time span from 1995-2016. Including more related variables to the residential house price of coastal municipalities would increase the statistical power and could generate a significance in the mean sea level. Secondly, the results are only applicable to the residential real estate market. Thirdly, only the impact of the variables that vary over time are analyzed and not between the municipalities. Since there are regional differences between municipalities this would be interesting for further research.

A follow-up study with more municipality-specific variables that explore both the differences between municipalities and the developments in time by focusing on different real estate seems extremely worthwhile for further research.

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7. Appendix

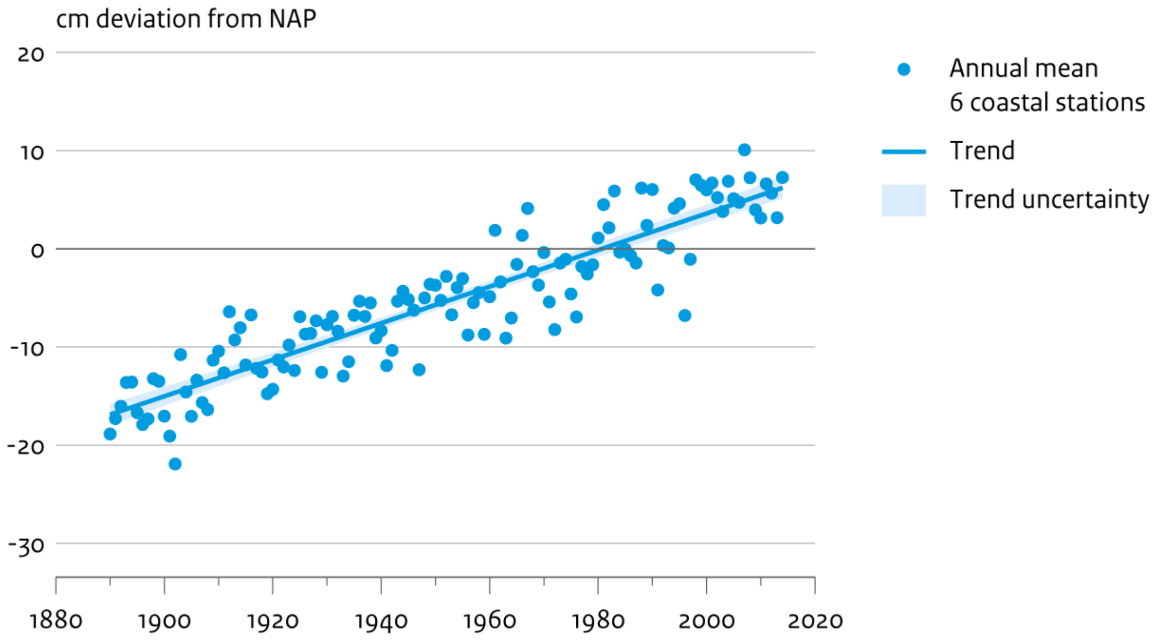

Figure 2: Sea level along the Dutch coast. Source: RWS; PSMSL, 2016

Figure 3: Currently about half of the country is below sea level and is therefore permanently threatened by flooding, if there would be no protection. Source: Bernardi et. Al. (2008)