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Bachelor Thesis [Economics & Business Economics]

The effect of elementary school test scores on housing prices

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Abstract

Introduction

This is a study on the effect of the quality of elementary schools on housing prices in the municipality of Rotterdam. Findings in existing literature strongly indicate an effect of the quality of elementary schools. This effect, found in existing literature, can be explained by the fact that people are willing to pay more in order to live close to a good elementary school. This effect has never been researched in the Netherlands, let alone Rotterdam.

Methodology

A hedonic pricing model is used in order to test the effect of the independent variable (test scores for different distance ranges) on the dependent variable (housing prices). Structural characteristics and neighbourhood effects have been added to the model as control variables. Adjusted test scores (adjustment done based on the method of Jaap Dronkers) have been used, test scores have been adjusted for the social, economic and cultural background of pupils. There are three different distance ranges in this research: within 350M, between 350 & 700M and between 700 & 1050M.

Results

For the first two distance ranges there is a substantial (6.3 and 6.1) but insignificant effect, at a 5% significance level. A significant and substantial effect (13.4) only existed for the distance range of 700 to 1050 meters. Townhouses and houses constructed after 1990 are generally more expensive compared to other houses. Surprisingly, these is a negative effect of the proportion of habitants younger than 15 years on housing prices.

Conclusion

Based on the statistical analysis conducted in this research there cannot be said that there is an effect of the test scores of elementary schools on housing prices. The insignificant effect is possibly caused by the use of adjusted test scores. Hence, this research might give a biased view on this topic.

Thesis

1. Introduction and research question

1.1 Introduction

Recently the Dutch government has published a report on inequality among children in education (de Groot, 2016). Children from different socio-economic backgrounds do not have the same chances in terms of education and this inequality is increasing.

This is a study on the effect of the quality of elementary schools on housing prices in the area of the municipality of Rotterdam. If the effect of quality of elementary schools would have an effect on housing prices in the neighbourhood, then this could lead to disproportional differences in prices of real estate property. Gibbons & Machin (2008) state that schools are one of the major factors in the residential decisions of families. Elementary schools are financed by the government and an effect of the quality of these schools on the housing prices is an unintentional effect of the government policy (Li, W., 2012). In other words, there is possibly a difference in housing prices among different neighbourhoods caused by disparities in school quality. This difference could be considered disproportional because it is an unintended effect of a government policy.

It is common in larger cities that residents of certain neighbourhoods lobby with the municipality for special programmes and better facilities for the school in their neighbourhood (Jud & Watts, 1981). Unsurprisingly, these lobbying efforts are often in favour of richer neighbourhoods. With the use of these lobbying efforts, parents do not solely try to protect the educational welfare of their children but they also do it to preserve and enhance the value of their real estate property (Jud & Watts, 1981).

1.2 Research question

The research question of this study is:

What is the effect of the quality of elementary schools on housing prices in the municipality of Rotterdam?

The reasoning behind the research question is that people are willing to pay more in order to live close to amenities. Mulligan and Carruthers (as cited in Ballas, 2013) define amenities as follows: ‘‘site- or region-specific goods and services, of either the private or public variety, that make some locations particularly attractive for living and working. Their opposites, disamenities, make places unattractive’’. Amenities can be natural, for example proximity to a

lake, climate or air quality. Moreover, amenities can be human-created, for instance health and education services, a retail area or a public park. Accordingly, the latter type of amenities has become increasingly important for the success of cities (Mulligan, Carruthers & Cahill, as cited in Ballas, 2013). Brown and Moore (as cited in W. Li, 2012) claim that households prefer to move to a neighbourhood with better amenities. Furthermore, Glaeser, Kolko & Saiz (2001) identified good public services, for instance schools, as one of the four critical urban amenities for cities. According to them, dropout rates among teenagers had a strong negative correlation with the growth of cities in the United States between 1970 and 1990. Good public services, like good schools and less crime, attract a highly educated workforce (Glaeser et al.,2001). Glaeser (1995) suggests that the good education then creates further growth, which implies a multiplier effect. Since schools are considered to be such an important amenity, it is likely that people are willing to pay more in order to live in cities with good public services. Higher demand for housing drives up the housing prices.

Two hypotheses are stated in order to answer the research question, these hypotheses are defined as follows:

H1: The adjusted test scores of an elementary school have a positive effect on the housing prices in the neighbourhood.

H2: The effect of adjusted test scores on housing prices decreases with distance.

The adjusted test scores are used as a measure for elementary school quality, the reason for this is explained in the conceptualisation section. For the second hypothesis, three different distance ranges are analysed. This is also explained in the conceptualisation.

1.3 Social relevance

To my knowledge, this topic has never been researched in the Netherlands. If an causal effect similar to the effect in the UK, US and Shanghai would exist, then both homeowners and real estate developers can use this to their advantage. First of all, habitants of neighbourhoods with lower quality elementary schools can lobby with the municipality in order to improve the quality of the nearby elementary school. If the municipality allocates more resources to specific elementary schools, this can lead to an improvement of the educational welfare of the children living nearby and it can increase the value of nearby properties. Furthermore, the NVM (Dutch Society of Real Estate Agency) can take the results of this research into consideration when valuing property. Lastly, project developers can use the information to their advantage. If there is indeed an causal effect of quality of elementary

schools on housing prices, then project developers can take this into consideration when making a decision where to build a property.

The remainder of the paper is organized as follows: First of all, an overview of existing literature on this topic is presented. Furthermore, an empirical analysis for the case of Rotterdam is presented. Additionally, the conclusion is given and based on this conclusion policy recommendations are made. Lastly, the limitations of this research and implications for further research are presented.

2. Literature review

In this section of the paper examples of prior research on this topic are presented. Additionally, the conceptualisation of comparable research is discussed. Based on this, a conceptualisation for this research is presented. The variables that are defined in this section of the paper are the quality of elementary schools, the structural characteristics of houses, neighbourhood characteristics and finally the housing prices. At last, the methodology (which is based on existing literature) of this research is explained.

2.1 Examples of empirical studies into the topic

A significant amount of research has been conducted on this topic in the United States. Kain and Quigley (1970) analysed the effect of the median schooling of residents on housing prices in St. Louis, Missouri. Their results showed a significant effect: a house in an area in which the median adult completed tenth grade would rent for $5.24 more compared to an area in which the median adult only completed eight grade, ceteris paribus (Kain & Quigley, 1970). Even though the study focussed on the level of education of the parents, it is still comparable to the research question of this study. Moreover, M. Li and Brown (1980) conducted research on the effect of micro-neighbourhood externalities on housing prices. Their research showed that there was no significant effect of either the percentage of 16 to 21 years old high school dropouts or the test scores of fourth graders on housing prices. These results could be explained by the fact that there was free provision of school bus service in the sample communities (Li, M & Brown, 1980). Another research on this topic was conducted in Charlotte, North Carolina, by Jud & Watts (1981). These researchers measured school quality by third-grade reading-levels of children; they found a strong significant effect of school quality on housing prices. Jud & Watts (1981) claim that an increase of one level in neighbourhood schools leads to an increase of 5,2% to 6,2% in the value of the average house. Besides quantitative evidence, there is also qualitative evidence for the effect of

school quality on housing prices. For instance, a survey conducted by the California Public Education Partnership shows that residents value enhancements in school quality higher than issues like reduction of crime or environmental quality (Clark & Herrin, 2000).

Apart from research in the USA, research has also been conducted in the UK. Gibbons & Machin (2003) analysed the effect of Key Stage 2 test scores on housing prices in London. Their results show that a 10% increase in the proportion of children reaching the target level in Key Stage 2 test at the age of eleven generally leads to 6.9% increase in housing prices.

The results that are going to be found in this research are only partially comparable to the results from abovementioned studies because the proportion of pupils attending private elementary schools in the UK and the US is higher than the proportion in the Netherlands.

Apart from research conducted on this topic in the U.S. and the U.K., research has also been conducted on this topic in other countries. A study by W. Li (2012) showed that there is a significant effect of school quality on prices of houses in the neighbourhood in Shanghai. Moreover, W. Li states that the quality of schools is a dominant factor in the consumers' decision making process in the housing market. Surprisingly, in some districts of Shanghai housing prices were more dependent on the school quality than the distance to the centre of a business district (Li, W., 2012).

There are two different visions on the disparities in housing prices caused by neighbourhood attributes. On the one hand, people argue that there is an effect of neighbourhood characteristics on housing prices because it is beneficial to live close to positive amenities like a park or a high quality school. On the other hand, people argue that these positive amenities give the neighbourhood a certain image and thus houses in these neighbourhoods are more expensive compared to similar houses in other neighbourhoods.

Empirical evidence from England shows that the school quality of primary schools is more important compared to secondary schools regarding the valuation of houses. This is most certainly the case because primary schools have a smaller catchment area (Cheshire & Sheppard, 2004; Gibbons & Machin, 2003). Whereas secondary school pupils are fairly mobile, children usually attend schools which are within walking distance, especially in urban areas (Gibbons & Machin, 2003). Hence, this research focusses on test results of elementary schools.

2.2 Conceptualisation

2.2.1 School quality

In prior research two main categories of measures of school quality were typically used: input-based and output-based. Expenditure per pupil is mostly used as input-based measure whereas standardized test scores are mostly used as output-based measure (W. Li, 2012). Besides, input-based and output-based measures have been combined in prior studies on this topic. For example, M. Li and Brown (1980) used both expenditure per pupil and standard test scores for fourth-grade pupils in their research. Moreover, W. Li (2012) defined certain elementary schools as 'top-tier' schools based on education reports including both output-based and input-based measures. As for the standardized test scores, several types were used in prior research. First of all, Jud and Watts (1981) measured school quality by third-grade reading levels. Furthermore, Kain and Quigley (1970) used the grade completed by the median adult in a neighbourhood. Lastly, Cheshire and Sheppard (2004) used the most recent Key Stage 2 test results prior to the date of the sale of the house. This test is usually taken by children of the age of 11 and thus it is comparable to the Cito-test in Holland. Similarly, Machin & Gibbons (2003) used Key Stage 2 test results as measure for school quality in their research in London.

This research uses the Cito-test results for the academic year 2015/2016 as a measure for school quality of elementary schools, these results are similar standardized test scores. The Cito-test, or a highly similar test like the threshold-test 678, is obliged for children in the last year of the elementary school, which is the eighth grade in the Netherlands ([Explanation Cito-test],(n.d.)). Even though other tests are allowed in the eighth grade, the CITO-test is the standard. Unfortunately, standardized test scores often correlate with socio-economic factors used as control variables in the regression. Hence, a multicollinearity problem most likely arises when using standardized test scores (W. Li, 2012). In order to avoid the problem of multicollinearity adjusted Cito-test results are used in the regression.

The Cito-test scores are adjusted based on a method by Jaap Dronkers (2013), his method adjusts Cito-test scores for the social, economic and cultural background of the pupils. By doing so, the added value of elementary schools can be analysed. The added value of an elementary school can be perceived as the extent to which the average Cito-test score of a school differs from the average score from all schools with an identical population of pupils. Thus, a school with an average Cito-test score which is higher than the average score of all elementary schools with an identical pupil population has positive added value. Unsurprisingly, a positive added value implicates that the school is of high quality whereas a negative added value implicates that the school is of low quality (Dronkers, 2013). Even

though this method was invented by Jaap Dronkers in collaboration with RTL in 2013, it is the exact same method as the method used for the adjustment of test scores in 2015/2016 ([Notification adjustment testscores, 2016). Unfortunately, the adjustment of the test scores is based on a calculation for the whole country instead of just Rotterdam. However, it most certainly remains the best estimation of school quality available.

Further explanation on the method of Jaap Dronkers can be found in the Appendix 1.

2.2.2 Schools

Elementary schools, mostly consisting of children aged 6 to 12, are generally a public good in the Netherlands. Some children go to a private elementary school but in 2009 there were only 24 private elementary schools in the Netherlands ("Hoe kies je een goede particuliere basisschool?", 2009). Hence, this study only focusses on public elementary schools. A good can be defined as a public good when each individuals' consumption of the good leads to no subtraction from the consumption of another individual (Samuelson, 1954).

There exists a constitutional law in the Netherlands which states that there is freedom of education. Yet, this does not guarantee children admission to a school preferred by their parents. In the case of too many applications, an elementary school can apply its own priority rules. For example, priority is sometimes given to children with siblings at the school (Weghorst, (n.d.)). Similarly, this priority criteria is also used in the UK for excellent primary school which are mostly oversubscribed (Gibbons & Machin, 2003). Moreover, elementary schools in the Netherlands and the UK give priority to children living in certain postal codes (Weghorst, (n.d.); Gibbons & Machin, 2003). Interestingly, Weghorst (n.d.) states that it is not forbidden by law to make a distinction based on household composition or place of domicile.

In conclusion, there is academic freedom in the Netherlands but above mentioned criteria make it most likely that parents put their children on the school which is the closest. Moreover, it is time consuming to bring children to a school which is not close five days a week. Hence, this paper assumes that it is most certainly that children go to the closest school.

Elementary schools are completely subsidised by the government and therefore free of charge. However, the voluntary parental contribution differs among schools. Even though this contribution is voluntary, children are exempted from certain educational activities if the parents do not pay the contribution ([Costs elementary schools] (n.d.)).

2.2.3 Structural characteristics of houses

A major problem is encountered when comparing housing prices, namely the fact that different structural characteristics also lead to disparities in housing prices. Therefore,

structural characteristics have to be added to the regression as control variables in order to eliminate the effect of structural characteristics on housing prices. Figlio and Lucas (2004) included basic characteristics like the square footage, number of bedrooms, general condition of the house and lot size. According to W. Li (2012), the age of the house and the bedroom facing direction should also be included in the model.

Sirmans, Machpherson & Zietz (2005) conducted literature research on the effect of structural and neighbourhood characteristics on housing prices. This was done by counting the number of negative, insignificant and positive coefficients of these characteristics found in prior research. The characteristics used in this research are chosen partly based on the findings of Sirmans et al. (2005). In this research the following characteristics are used:

- Apartment or house. Generally, houses are more expensive than apartments. A dummy variable is created, 0 if the property is a house and 1 if it is an apartment. Houses are omitted from the regression model in order to prevent perfect multicollinearity.
- Type of apartment, the following groups are distinguished: Ground floor apartments, upstairs apartments, maisonettes, porch flats, access-balcony flats and 'other' types of apartments. In order to prevent the problem of multicollinearity, access-balcony flats are omitted from the regression.
- Age of the house, this is the most used characteristic in hedonic pricing models of housing prices (Sirmans et al., 2005). The effect of age on the housing price is expected to be negative but it has also been positive or not significant in prior research. This could be explained by the fact that some people prefer an authentic house like a townhouse. This type of housing is popular in the Netherlands and these houses are constructed in the period 1500-1905. The NVM has data available on the year of construction, dummy variables are made of the following periods: 1500-1905, 1906-1930, 1931-1944, 1945-1959, 1960-1970, 1971-1980, 1981-1990, 1991-2000 and > 2000. One period (1906-1930) is left out in order to prevent the problem of multicollinearity.
- Square footage, also used by Figlio and Lucas (2004) and several other researchers. This is the second most used characteristic in hedonic pricing models (Sirmans et al., 2005). Similarly to prior research, a logarithm is used to include this variable in the regression because the housing prices do not increase proportional with the square footage (Palmquist, 1984). Palmquist states that the latter is the case because the constructions costs do not increase proportionally with the number of square feet.

2.2.4 Neighbourhood characteristics

Besides schools there are other amenities that affect housing prices. Therefore, the neighbourhood characteristics influencing housing prices have to be added to the regression model as control variables in order to rule out the effects of these characteristics per se. An omitted variable would arise if neighbourhood characteristics have an effect on housing prices and correlate with school quality. Hence, as many neighbourhood characteristics which could cause an OVB should be added to the regression. Data on neighbourhood characteristics is obtained from the Central Bureau for Statistics (CBS) ([Wijk- en buurtkaart 2015], (n.d.). Firstly, a major proportion of prior research has used distance to the central business district (CBD) in hedonic pricing models. According to Sirmans et al. (2005), distance has shown both positive and negative effects in prior research. The negative effect can be explained by the fact that employment nowadays is dispersed instead of solely being located in the CBD (Palmquist, 1984). Similarly, a major proportion of companies is located at other locations than the CBD in Rotterdam, for instance Brainpark. Hence, distance to the CBD is not included in the regression model. In lieu of this, employment in the neighbourhood are taken into consideration and this is known to have a positive effect on housing prices in the Netherlands (Visser, Van Dam & Hooimeijer, 2008). The CBS published data on the number of companies per neighbourhood, specified to sectors. This research uses the following variable in the hedonic pricing model: The number of companies which offer high-quality employment like financial & business services and real estate is divided by the total number. Secondly, population density is added to the hedonic pricing model. This variable is known to have a negative effect on housing prices (Katz & Rosen, 1987). The CBS published data on the number of people in every neighbourhood divided by the square footage of the neighbourhood. Thirdly, proximity to retail stores is added to the hedonic pricing model. This variable is also expected to be positive (Song & Knaap, 2004; Bowes & Ihlanfeldt, 2001). The retail proximity is measured in actual distance (i.e. distance measured over the road and not linear distance) to a retail centre. The Central Bureau of Statistics published data on the average distance of residents in one neighbourhood to a warehouse. However, the neighbourhood level is not exactly the same as the assigned postal code. Fortunately, the CBS has also published data on the proportion of addresses in a neighbourhood with the same 4-digit postal code. In the case of Rotterdam, most of the neighbourhoods contain more than 90% percent of addresses with identical 4-digit postal codes ([Wijk- en buurtkaart 2015], (n.d.). Hence, the analysis of retail proximity on neighbourhood level is most certainly suitable for this research. Fourthly, the proportion of people younger than 15 years are added as a variable.

2.2.5 Housing prices

Transaction data of the sales of houses are used to measure the housing prices. Similarly, transaction data has been used in prior research. Figlio and Lucas (2004) used panel data of transaction data of single-family houses. Houses can change substantially between moments of sale. However, this only affects the housing prices through the structural characteristics of the houses. Hence, this does not lead to omitted variable bias if the structural and neighbourhood characteristics are used as control variables. The implicit price of a house can be seen a function of its structural characteristics, neighbourhood characteristics and the quality of the school in the neighbourhood.

Housing price data was obtained from the NVM, the data contained transaction data of all houses sold in the municipality of Rotterdam in the period 2015 and 2016. Transaction data is preferred to the values of real estate property based on the Valuation of Real Estate Act (WOZ). This because it represents the actual value of the house and its attributes whereas the value based on the Valuation of Real Estate Act is roughly estimated. To estimate the latter value an appraiser looks into detail about the building and the lot on which the property is located. Besides, comparable property which is sold around the same valuation date is analysed ("Hoe bepalen gemeenten de WOZ-waarde?", n.d.). However, the NVM only owns a proportion of the houses in Rotterdam whereas the cadastral value is estimated for all property, including rental property. In conclusion, the advantages of the NVM data most certainly outweigh the disadvantages.

2.3 Methodology

2.3.1 Hedonic pricing model

The hedonic pricing model invented by Rosen (1974) is used in this paper to analyse the prices of houses. Rosen defines hedonic prices as the implicit price of goods and attributes. These implicit prices are revealed by price disparities among differentiated products and the specific number of characteristics associated with them (Rosen, 1974). According to Sheppard (1999), hedonic price functions are estimated for two reasons. Firstly, these functions are estimated as an input in the analysis of consumer demand for attributes of heterogenous goods. Secondly, they help to make overall price indices that account for changes in the quality of goods produced (Sheppard, 1999).

Houses are heterogenous goods and thus it useful to use the hedonic pricing model for the housing market (Sheppard, 1999). The idea in the case of housing prices is that houses are

not only valued by customers for the value of attributes of the house itself but also for attributes in the neighbourhood (Gibbons & Machin, 2008). Apart from a certain number of rooms, square footage etc. a house also has other attributes like proximity to schools, parks and jobs. Both the structural characteristics of a house and the neighbourhood characteristics have to be added to the hedonic pricing model in order to rule the effects of these characteristics per se. By estimating the change in housing prices caused by a marginal change in test results, ceteris paribus, the causal effect of school quality on housing prices is analysed. This can be interpreted as the marginal willingness to pay for school quality, also defined as the implicit price (Gibbons & Machin, 2008).

Mathematically the hedonic pricing model in this research looks as follows:

$$Ln\ (P_{it}) = \alpha + B_x * X_i + B_2 * Z_{it}$$

Where P_{it} is the price of a property at time t in zip code i. X_i is the quality of the elementary school is zip code I whereas structural characteristics of the house and neighbourhood characteristics are included in Z_{it}.

In prior research on housing prices the hedonic pricing model has been the standard because houses and other types of real property are unique products, almost every unit of real property is unique (Palmquist, 2005). The complexity of the real estate market makes the hedonic pricing model most certainly suitable for this research. Houses are differentiated products, i.e. they are traded on one single market but there exist major differences among different units (Palmquist, 2005). Even though most of the supply on the real estate market consists of existing houses, real estate developers can react on excess by building new houses. However, the construction of houses take time and thus the supply is fixed in the short-run. Consequently, demand determines the prices of existing houses (Palmquist, 2005).

2.3.2 Distance models

The effect of test scores on housing prices is estimated for three different ranges of distance. Firstly, the coefficient of the average of weighted test scores of elementary schools within 350 meters is estimated. Secondly, the effect is estimated for elementary schools located between a range of 350 and 700 meters of a property. Thirdly, the effect is estimated for a range between 700 and 1050 meters. These ranges are not randomly chosen. The median person walked approximately twelve minutes to school or for a school related trip (Iacono, Krizek & El-Geneidy, 2008). Furthermore, the average walking speed of pedestrians is approximately five kilometres per hour (Knoblauch, Pietrucha, & Nitzburg, 1996). Hence, it can be assumed that people are generally willing to walk one kilometre to go to school.

However, the linear distance from a house to an elementary school is not equal to the actual distance walked, especially in dense urban areas like Rotterdam. The latter can be estimated by dividing the actual distance (as the crow flies) by 1.41, assuming the city has a perfect grid structure. A perfect grid structure means the city has a non-hierarchal system with blocks which are identical in size (Figueiredo & Amorim, 2007). Appendix 3 contains images which explain both the choice for dividing by 1.41 and the perfect grid structure. In order to calculate the distances from houses to nearby elementary schools, QGIS is used. This program calculates the linear distance and thus the actual walked distance over the road has to be estimated. Dividing 1,000 by 1.41 results in approximately 709. Schools in multiple ranges of distances are evaluated, namely schools within a range of 350 meters, schools in a range between 350 and 700 meters and schools in a range between 700 and 1050 meters.

2.3.3 The model

Based on the existing literature, the following model can be compiled:

Logarithm of price
Square meters
Apartment
Period of construction: 1500-1905
Period of construction: 1931-1944
Period of construction: 1945-1959
Period of construction: 1960-1970
Period of construction: 1971-1980
Period of construction: 1981-1990
Period of construction: 1991-2000
Period of construction: >2001
Type of apartment: Ground floor apartment
Type of apartment: Upstairs apartment
Type of apartment: Maisonette
Type of apartment: Porch flat
Type of apartment: Gallery flat
Retail proximity
Proportion of high-quality employment
Population density
Proportion of habitants <15 years
Number of elementary schools within 350 meters
Number of elementary schools between 350 and 700 meters
Number of elementary schools between 700 and 1050 meters
Logarithm of average score of schools within 350m

Logarithm of average score of schools between 350m and 700m
Logarithm of average score of schools between 700m and 1050m
Constant

The dependent variable is the logarithm of the price and the independent variables of interest are the logarithms of the average scores of the schools for the different distance ranges. The 'log-log' coefficients of the variables of interest can be interpreted as follows: A coefficient of X means that if the logarithm of the average score goes up by X%, then the price of the houses goes up by X%. The other variables have 'log-normal' coefficients. Suppose one of the other variables has a coefficient W. This means that if the variable goes up by W, then the logarithm of the price goes up by W%.

In order to account for correlation between error terms (which violates their normality), standard error are clustered by neighbourhood. An example of correlation between errors in this research would be the effect of a burglary wave on the housing prices. The burglaries only takes place in a small proportion of the houses in the neighbourhood, but may affect the housing prices in the entire neighbourhood.

3. The case of Rotterdam: empirical analysis

In this section of the paper the available data are presented.

3.1 Overview of data

As previously mentioned, data on the weighted scores was obtained from RTL (Beunskoek, 2016). Coordinates for every elementary school in the municipality of Rotterdam were manually obtained from Google Maps GPS Coordinates. However, a minor proportion of schools do not exist anymore and thus it was not possible to retrieve the coordinates of these schools. Hence, these schools were removed from the dataset and 171 schools remained.

The coordinates of the elementary schools and the corresponding weight test scores were transferred to QGIS, the map is presented in Appendix 2. Based on this map some elementary schools omitted due to geographical reasons. The elementary schools which omitted were located in Hoogvliet, Pernis, Rozenburg and Hoek van Holland. After omission these schools, 151 elementary schools were still in the dataset.

The average weighted score in the municipality of Rotterdam (after omission) was 532.1960 in the academic year 2015/2016. Apart from the weighted scores, the dataset also contained

information on the denomination of all schools. As previously mentioned, a distinction can be made between public and special schools, the summarized data is presented in the table below:

Denomination	Number of schools	Average score
Special	95	532.552
Public	56	531.2834

This indicates an effect of denomination on the weighted test scores. Hence, a further distinction is made between the different types of special schools. The table below contains summarized data of the schools:

Denomination	Number of schools	Average score
General/Anthroposophical	10	537.9731
Reformed/Reformed liberated	2	536.7337
Hindu	1	533.3438
Islamic	3	530.289
Public	56	531.2834
Protestant-Christian/ Roman-Catholic	79	531.8358

Several denominations were combined because of high similarities. First of all, ‘general special’ and ‘anthroposophical’ schools are combined because they both fall under the category special even though they are not confessional. Furthermore, Reformed and Reformed Liberated schools are very similar in their denomination. Lastly, Protestant-Christian and Roman-Catholic schools are combined for the same reason.

Interestingly, general special and anthroposophical schools have the highest average weighted score, followed by Reformed and Reformed Liberated schools. Thus, there is a strong indication that there is an effect of denomination on the weighted test scores.

The neighbourhood characteristics were mostly obtained from the CBS. The CBS published data on all areas in the Netherlands. However, some of these areas are industrial terrains or business areas. In these areas there are no properties for the purpose of living and hence these areas are omitted from the data.

Unfortunately, data on the percentage of sale property and the percentage of low incomes was not available for the year 2015. However, the CBS did publish data on these percentages for the year 2014 and thus these are used in the model. The data of 2014 is most likely a good estimate of the data in 2015. Yet, data on abovementioned variables was not available for postal codes 3022, 3029 and 3035. Therefore, the average scores on these variables for all other postal codes were used to estimate the missing values. Moreover, there were eleven double or triple postal codes. A weighted average of these postal codes was taken based on the number of citizens in every part of the postal code.

The data of the NVM on the type of property also included garages and construction sites. Because of the fact that families do not live in these type of properties transaction data on these properties is omitted from the dataset. The data from NVM contained the postal code, street name and number of every house. By using the PDOK BAG Geocoder it was possible to obtain coordinates for all addresses. However, only 10297 of the 10502 coordinates could be found. Moreover, the outer areas of the municipality of Rotterdam were filtered out of the data. Consequently, 9605 observations remained in the dataset. Lastly, properties under the categories garage boxes and construction sites were removed which led to a final number of 9565 observations.

A Python script was conducted in QGIS in order to calculate the number of elementary schools in a radius of 350, a radius between 350 and 700 meters and a radius between 700 and 1050 meters from every one of the 9565 houses. Subsequently, the average weighted score of the elementary schools within the respective radius was calculated for every house in the remaining dataset.

3.2 Regression results

At last, a regression was conducted in STATA. The 4-digit postal code was clustered in order to prevent perfect multicollinearity. The results of the 500M model are shown in the figure below:

	R-Squared = 0.2792	
Logarithm of price	**Coefficient**	**P>t**
Logarithm of average of score of schools within 350m	6.2965	0.115
Logarithm of average of score of schools between 350m and 700m	6.0887	0.108
Logarithm of average of score of schools between 700m and 1050m	13.3578**	0.008

Square meters	.0019**	0.000
Apartment	-.2453**	0.000
Period of construction: 1500-1905	.1265	0.089
Period of construction: 1931-1944	-.1053	0.344
Period of construction: 1945-1959	-.1782	0.081
Period of construction: 1960-1970	-.0812	0.447
Period of construction: 1971-1980	-.1026	0.402
Period of construction: 1981-1990	-.0201	0.838
Period of construction: 1991-2000	.1319	0.138
Period of construction: >2001	.2475 **	0.005
Type of apartment: Ground floor apartment	.2914**	0.006
Type of apartment: Upstairs apartment	.4327**	0.000
Type of apartment: Maisonette	.3650**	0.000
Type of apartment: Porch flat	.3787**	0.001
Type of apartment: Gallery flat	.3783**	0.000
Retail proximity	.0010	0.051
Proportion of high-quality employment	1.8936**	0.000
Population density	0.0000	0.449
Proportion of habitants <15 years	-.8904	0.374
Number of elementary schools within 350 meters	-.0497	0.109
Number of elementary schools between 350 and 700 meters	-.0022	0.870
Number of elementary schools between 700 and 1050 meters	-.0126	0.351
Constant	-150.9041**	0.004

**Significant at 0.05. The regression is not robust but the clustering by neighbourhood has accounted for heteroscedasticity (this has been tested in STATA).

There is no significant effect of the test scores of elementary schools within 350M of real estate property on the housing prices. Yet, the effect is substantial. An increase of 1% of the test scores of elementary scores within a radius of 350 meters approximately leads on average to an increase of 6.3% . Since the effect is insignificant, this result is not externally valid. It only implies an effect on the prices of the real estate property in the NVM dataset. Similarly, the effect in the range of 350 to 700 meters is substantial (6.1) but insignificant.

In the range of 700 to 1050 meters, however, the effect of test scores on housing prices is both significant and substantial. For every increase in percentage of the weighted average test scores, the prices of real estate property increase approximately by 13.4%. This result is externally valid because the effect is significant.

Unsurprisingly, there is an significant effect (1.9) of the proportion of high quality employment on real estate property. The construction period has a significant effect for the period 1991-

2000 and after 2000 (0.1 and 0.3, respectively). This was expected since people generally have a preference for modern houses. Moreover, there is a significant effect of houses being constructed in the period 1505-1905 on housing prices (0.2). As previously mentioned in the literature review, townhouses (which are constructed before 1905) are popular in the Netherlands.

Surprisingly, there is a substantial and significant negative effect of the proportion of young habitants (<15 years) on housing prices. This effect can (intuitively) be explained by the fact that parents with young children have less capital and thus live in a neighbourhood with cheaper houses. Older people (with children that moved out) have generally saved more money throughout their life and they can afford more expensive houses.

4. Conclusion

4.1 Summary

The research question of this study was: *What is the effect of the quality of elementary schools on housing prices in the municipality of Rotterdam?*

The following hypotheses were stated in order to answer the research question:

H1: The adjusted test scores of an elementary school have a positive effect on the housing prices in the neighbourhood.

H2: The effect of adjusted test scores on housing prices decreases with distance.

Even though there is a substantial effect of the adjusted test scores on housing prices, the first hypothesis is still rejected since the effect in the first two distance ranges is insignificant. Surprisingly, the effect of adjusted test scores on housing prices increases with distance. Hence, the second hypothesis is also rejected.

In conclusion, there is a significant effect of school quality on real estate property in only one of the three distance ranges. The magnitude of the effects found in this study are comparable to the effect found in previous studies on the same topic. Yet, the results found in this study differ from the results found in previous research because the results of two distance ranges were insignificant. A possible explanation for this might be the use of the adjusted test scores (based on the method of Jaap Dronkers). The adjustment was done based on the social, economic and cultural background of pupils of an elementary school. This may have already accounted for disparities in prices of real estate property in the neighbourhood of an

elementary school. Hence, the results found in this study most likely gives a biased view on this topic.

4.2 Policy recommendations

In this section of the paper policy recommendations are made based on the results. The following recommendations have to be made with great reservation because the effect in the two closest distance ranges (0-350M & 350-700M) are not externally valid. In fact, the policy recommendations can solely be made for real estate property in the dataset. This means that it is only relevant for houses owned by the NVM located in the selected areas in the municipality of Rotterdam. Besides, the use of the adjusted test scores as variable of interest most likely has led to results which are biased. The recommendations are as follows: First of all, real estate owners can lobby with the municipality for allocation of more resources to the elementary school in their neighbourhood. An increase of school quality is not only beneficial for the educational welfare of the children but it also leads to an increase of the value of the real estate property. Besides, households looking for a new house should take the quality of schools in a neighbourhood into consideration. Furthermore, the NVM should take the results of this research into consideration in the valuation of real estate property. Lastly, real estate developers should look for locations which are close to high quality elementary schools or at least take the effect into consideration.

5. Limitations and implications further research

5.1 Limitations

In this section of the paper limitations posed by this research are stated and recommendations are done for further research. To start with, there are some limitations in this research caused by the use of the method by Jaap Dronkers for the adjustment of the test scores:

- First of all, comparison of schools is done which are similar in their socio-demographic composition (see Appendix 1). However, the schools in the municipality of Rotterdam are compared with schools in the whole country instead of just schools in Rotterdam.
- Furthermore, the socio-demographic composition of pupils is based on the whole school instead of just the pupils in the eighth grade in order to prevent distorted results (Appendix 1). Nonetheless, the added value of schools which have gone through major changes of their pupil population in recent years might be incorrectly estimated. This because of the fact that the characteristics of children in the eighth grade might be substantially different from the pupils in lower grades.
- Lastly, the socio-economic composition of pupils is based on the postal codes in which they live. Unfortunately, solely the aggregated data of the socio-economic situation was available due to privacy reasons. Hence, this might have led to a slightly incorrect estimation of the socio-economic situation of the pupils.

Apart from the limitations caused by the use of the method by Jaap Dronkers, this research poses some other limitations. Firstly, only transaction data on houses was available because it is not standard at all for households to hire professionals to value their house every year. This poses a limitation to this research because a major proportion of houses in a neighbourhood are not included in the regression. Besides, it is plausible that houses change substantially between moments of sale due to renovation, extension or new amenities in the neighbourhood (Figlio & Lucas, 2004). Moreover, only houses available for sale are included in the regression whereas houses for rent are not taken into consideration. The latter poses a limitation to this research because the distribution of sale and rental property differs among neighbourhoods. Besides, a proportion of all houses in Rotterdam are rental houses.

Secondly, this research only focusses on the municipality of Rotterdam. This poses an threat to the external validity of the third distance model (700-1050M) in this research because it is questionable if these results can be generalized to other parts of the Netherlands. Whereas

Rotterdam is comparable to other cities in the Randstad like Amsterdam or the Hague, rural areas in the, for instance, the North of the Netherlands are not that comparable. This needs to be taken into account regarding policy recommendations.

Thirdly, there is a problem involved with the identification of results because of the fact that income has an effect on both housing prices and the 'market' for schools. Due to lobbying efforts by parents, more resources are assigned to elementary schools in rich neighbourhoods. Moreover, children from parents with high incomes generally get more support from home, both mental support and in terms of resources (e.g. private tutors). Therefore, an omitted variable bias exists which cannot be restored by adding a control variable.

5.2 Recommendations further research

Because of the social and scientific relevance a more in-depth research on this topic is highly valuable. Regarding the limitations caused by the use of the method by Jaap Dronkers, the following actions are recommended for further research on this topic:

- First of all, if the effect of school quality on housing prices is researched in the future for a specific city or a specific area (e.g. the Randstad or the province North-Holland) then the adjustment of the test scores should be done based on comparison with the socio-demographic situation of similar schools in the specific city or area and not the whole country. Consequently, the adjustment of the test scores is more precise.
- Furthermore, a panel study should be done in order to prevent incorrect estimations caused by substantial changes in socio-demographic composition of schools in recent years.
- Lastly, individual data on the socio-economic characteristics on pupils should somehow be collected.

Apart from this, further research should include both the adjusted test scores and raw test scores. This could verify the possible explanation for the insignificant effects in the previous section.

Moreover, rental property should also be taken into consideration when estimating the effect of school quality on housing prices. Furthermore, the threat to the external validity can be prevented by conducting research in other areas than just the municipality of Rotterdam. In order to make policy recommendations for the Netherlands as whole, research should be conducted in areas besides the urban areas the Randstad. Lastly, further research should implement an instrumental variable in order to restore the problem of the omitted variable bias caused by income of parents. An example of an instrumental variable in this case would

be the introduction of the law which states that the CITO-test (or a highly similar test) is compulsory for schools. This law was introduced in 2013 (Gerrits, 2011).

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Note: n.d. means no date

7. Appendix

1) This section contains further explanation on the method of Jaap Dronkers. The test scores are adjusted for social, economic and cultural background of the pupils which are determined by the following factors:

- The number of children born outside the Netherlands in every elementary school. However, a distinction is only made for the following groups/countries: Aruba, the Moluccas, Greece, Italy, Cape Verde, Morocco, Netherlands Antilles, Portugal, Spain, Surinam, Tunisia, Turkey, Refugees and Former Yugoslavia. The numbers of children of abovementioned groups are converted to a percentage of the total number of children at an elementary school (Dronkers, 2013).
- The level of education of the parents, the test scores are weighted differently if one or both parents only completed specific types of education. Weights are assigned to children whose parents (or at least one of them) only completed elementary school and children whose parents (or one of them) completed the lowest levels of high school. Contrarily, a weight of 0 is given to children whose parents (or one of them) completed higher levels of education. These weighted number are divided by the total number of pupils at an elementary school (Dronkers, 2013).
- The last factor is the number of children living in specific types of postal codes. The Dutch government has evaluated every postal code based on several dimensions. Dronkers (2013) has used the 'demographics'-dimension because this dimension takes both income and education into account. Unfortunately, there is no information available on the socio-economic characteristics of the parents. Hence, information on the postal code in which the pupil lives is used to estimate the socio-economic composition of the parents ([Notification adjustment testscores], 2016). Data on the education of parents and the average income of households in the postal codes is retrieved for the Central Bureau of Statistics. For the education of parents a distinction is made between primary education, secondary education and higher education. Moreover, data on the composition of households is obtained from the Data Portal of the Dutch Government by RTL ([Notification adjustment testscores], 2016).

In abovementioned calculation all pupils of the elementary schools are included because contingent outliers in group 8 could lead to distorted results.

Not all pupils participate in the CITO-test, in 2013 98,85% of the pupils participated in the test. An adjustment is made for this with the method of Jaap Dronkers, namely, the average test score is lowered with 0.014 points for every percentage of non-participant. The latter is done because regression shows that test scores of a school are 0.14 points higher for ten

percent extra participants. Hence, scores are estimated based on a fictional situation in which all pupils participate in the CITO-test.

Moreover, a status score is assigned to every elementary school in the Netherlands based on an average score of the CITO test and highly similar tests. As previously mentioned, schools are also allowed to take other tests in the eighth grade but the CITO-test is the standard test in the Netherlands.

An OLS regression was made with abovementioned factors as independent variables and the real test scores of the academic year 2015/2016 as dependent variables. This regression can be presented mathematically as follows:

$$\text{Real test scores} = \beta_0 + \beta_1*\text{StatusSchool} + \beta_2*\text{StatusSchool}^2 + \beta_3\text{Weight03} + \beta_4*\text{Weight12} + \beta_5*\text{Aruba} + \beta_6*\text{Moluccas} + \beta_7*\text{Greece} + \beta_8*\text{Italy} + \beta_9*\text{CapeVerde} + \beta_{10}*\text{Morocco} + \beta_{11}*\text{NetherlandsAntilles} + \beta_{12}*\text{Portugal} + \beta_{13}*\text{Spain} + \beta_{14}*\text{Surinam} + \beta_{15}*\text{Tunisia} + \beta_{16}*\text{Turkey} + \beta_{17}*\text{Refugees} + \beta_{18}*\text{FormerYugoslavia}$$

The variable StatusSchool is squared to take schools with a major proportion of high test scores into account (Dronkers, 2013). By taking the mean of StatusSchool, or in other words the mean of the test scores, abovementioned regression can be used to calculate the expected test score of a school with a population of pupils with certain socio-economic factors. Consequently, a school can be compared to similar schools.

Furthermore, another regression was made in order to compare schools with a composition of pupils with a similar socio-economic background. This regression can be presented mathematically as follows:

$$\text{Score} = \beta_0 + \beta_1*\text{ProportionSecondaryEducation} + \beta_2*\text{ProportionHigherEducation} + \beta_3\text{IncomeHouseholds} + \beta_4*\text{CompositionHouseholds} + \beta_5*\text{Weight03} + \beta_6*\text{Weight12} + \beta_7*\text{ProportionPupilsNOAT}$$

The variables weight03 and weight12 are the same as the variables used in previous regression. Besides, NOAT means Dutch Education for non-Dutch Speakers and pupils with at minimum one parent born in one of the countries or included in one of the groups mentioned in the previous regression.

With the latter regression a result around zero is calculated. By adding seven to this result a final score is calculated. When the result of the regression is zero, the final score is seven and this means the school is perfectly equal to the expected score based on the first regression. However, if a school scores exactly one standard deviation above the expected score, a score of eight is assigned to the school. Contrarily, a score of six is assigned to

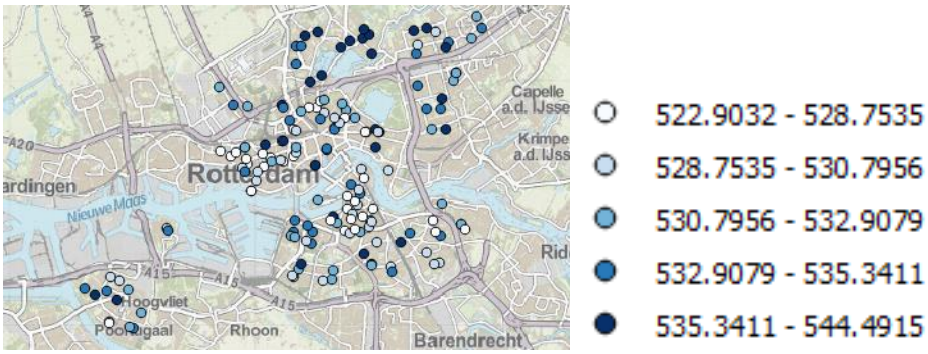
schools which score one standard deviation below the expected score ([Notification adjustment testscores], 2016).

At last, the weighted CITO-score can be calculated as follows:

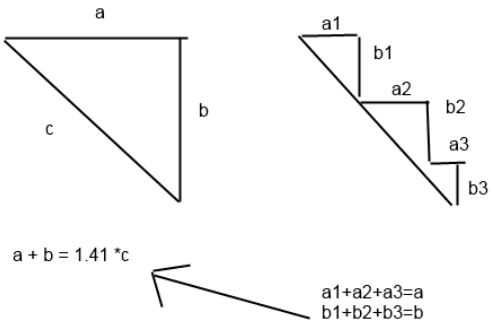
Weighted score = Expected test score + Score*StandardDeviation

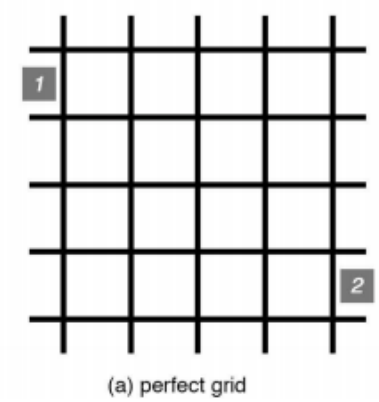
With Expected test score being the result of the first regression and Score being the result of the second regression with a value around zero and thus not the 'final score' with a value around seven. The average standard deviation in the Netherlands was 4.068 but the exact standard deviation differs among the different values of the expected test scores. However, it is most certainly a good estimation, namely, the weighted scores calculated with abovementioned standard deviation is almost equal to the weighted scores presented in the dataset by RTL.

2) The figure below shows a map of Rotterdam with all elementary schools and their weighted Cito score in the academic year 2015/2016.



3) In order to transform the distance over the road to the linear distance (as the crow flies) the following has to be taken into account: When moving from point one to point two a person cannot walk through the buildings (which are located between the black lines) and thus the person has to walk Southwards and Eastwards (a or b, respectively).





(a) perfect grid