# THE EFFECT OF BROKERS

## ON OFFICE INVESTMENTS

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## COLOPHON

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## EXECUTIVE SUMMARY

In real estate transactions buyers and sellers are often faced with information asymmetry, defined as the difference of information available to purchasers and sellers. One of the possibilities to reduce this information asymmetry is by using a broker. Investors have the choice to employ a broker or not. However, prior research showed that using a broker also influences the transaction prices. The research in this paper is aimed to understand the influence of the use of a broker on transaction prices per square meter of office investments in the Netherlands for the period of 2000-2007. The research focuses both on the use of a broker and the market share of a broker.

The research uses a hedonic regression as well as a spatiotemporal model to determine the effects of the use of a broker. The results show that price premiums are considered for investments when using a broker (3.6%), these price premiums are lower than those found in previous research which amounted to 7.7%. Results for a subsample of Amsterdam show similar effects of the use of a broker and amount to 3.7%. The effect of using a broker with a higher market share also results in price premiums on transaction prices amounting to a 0.5% increase.

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# 1 INTRODUCTION

One of the problems buyers and sellers are faced with is the information asymmetry between these two parties. Information asymmetry is defined as the difference of information available to purchasers and sellers (Leland & Pyle, 1977). To ease this information asymmetry a broker can be employed. Both buyers and sellers have the choice to work with a broker or not. One of the questions concerning the use of a broker is to see what this service impacts the transaction price (Levit & Syverson, 2008; Ling, et al., 2016).

In the academic literature, the topic of information asymmetry has been discussed for decades. Information asymmetry is often described as the difference of information available to purchasers and sellers (Leland & Pyle, 1977). In real estate information asymmetry leads to an increase of costs and a reduction of returns for an investor as a result of the cost that occur due to the lower level of information of the purchaser (McAllister & Nanda, 2016). Information asymmetry exists in various ways in real estate. First a seller possesses more information than a purchaser since he or she is better informed about the local dynamics as well as the building characteristics (Milgrom & Stockey, 1982; Geurts & Jaffe, 1996). Next to that, information asymmetry is also created by the distance of a purchaser (Ling, et al., 2016). More distant purchasers are faced with higher search costs which results in price premiums for foreign investors (Sheffrin, 2002). According to previous research purchasers at a further distance are faced with price premiums of 14.7% (Ling, et al., 2016).

Information asymmetry, when purchasing a real estate asset can occur as a result of the purchaser having less information compared to the seller. Information asymmetry can also occur as a result of the use of an information intermediary, a broker. The function of a real estate broker is to act on behalf of an investor (Gibson, et al., 1983; Webster & Hetrick, 1983). This is also what commercial real estate brokers such as JLL, Cushman & Wakefield and CBRE state. According to these brokers they supply transparent information, accompany sales and purchase properties under the best terms and conditions, and will help to achieve the highest revenues (JLL, 2018(1); CBRE, 2018; Cushman & Wakefield, 2018). However, according to the academic literature brokers do not always act in favour of the seller or the purchaser (Levit & Syverson, 2008; Ling, et al., 2016). Ling et al. (2016) has found that on average price premiums of 3% - 8% are seen when using a broker is in play. This price premium can happen when brokers convince sellers to sell too quickly and purchasers to search less; they both will pay price premiums. Finally, brokers are encouraged to achieve high transaction prices, since they are compensated for their service by a commission which is a percentage of the sale price (Garmaise & Moskowitz, 2004).

This research will focus on the effect of using a broker in office investments in the Dutch real estate market. It looks both at the effect of using a broker in general and more specifically the effect of the market share of the employed broker (Chan, 1983; Campbell & Kwacaw, 1980; Milgrom & Stockey, 1982).

To determine the effect of the use of a broker, a hedonic regression and a spatiotemporal autoregression analysis (STAR) will be used. A hedonic regression is the baseline model of the research. The STAR model is included, since this model captures the local structure of the market by modelling both space and time. The aim is to answer the following research question: how does the use of a broker during an office transaction influence the transaction price?

The research is organized as follows. First, an overview of the different theories of information asymmetry and the use of an information intermediary, such as a broker in the real estate market, will be discussed. Next, an empirical model will be developed to test the theories on the dataset. Afterwards, the obtained dataset will be reviewed, and several highlights of the dataset will be shown. Finally, the results of the analyses will be displayed in section 4 as well as a sensitivity analysis to further underpin the results. The final section will conclude the findings and implications of the research as well as recommendations for future research.

# 2 LITERATURE REVIEW

This chapter first highlights the basis of information asymmetry in different markets. Then, it will focus on information asymmetry in the real estate market. Afterwards, the different motives investors have for using a broker during a transaction process are addressed. Finally, at the end of the chapter the hypothesis for this research will be put forward.

The standard asset pricing theory assumes that all market participants have the same information, however, this is not the case. Some traders might have higher levels of information than others, and the same information can be interpreted in different ways which results in asymmetric information (Brunnermeier, 2000). Next to that, information asymmetry also characterizes the difference of information available to purchasers and sellers (Leland & Pyle, 1977).

The first researcher to explain the phenomenon of information asymmetry was Akerlof (1970). For his explanation Akerlof (1970) used an example of second hand cars in the United States, in which the old and defect cars were called 'lemons'. He explained that in the second hand car market, information asymmetry is seen by the different levels of information held by the agents. A seller holds the full information on the car, whereas the purchaser does not have complete information on the condition of the car. Therefore, a purchaser is only prepared to pay a price that is below the actual value. As a result, a seller that possesses a good car will resist on selling it (Akerlof, 1970).

Information asymmetry also occurs in the financial markets. This information asymmetry exists because borrowers know their guarantees, skills and moral integrity better than the lenders. Moreover, the borrower has insider knowledge on the project for which he seeks financing (Leland & Pyle, 1977). Therefore, lenders should be able to assess the borrower's moral hazard and to understand the true characteristics of the project (Leland & Pyle, 1977).

In capital markets information asymmetry is the result of the differences between information that traders will have. This difference in information shows that traders will hold different portfolios and securities (O'Hara, 2003; Easley & O'Hara, 2004). Less informed traders that recognize this information disadvantage prefer to hold assets in which their disadvantage is limited (O'Hara, 2003; Easley & O'Hara, 2004). Different degrees of information held by individuals will also result in differences in prices (Lambert, et al., 2012). These differences are the result of firstly the investors precision-weighted average assessment of firms expected end-of-period cash flows and secondly a discount for the risk the investors take, holding shares in a firm depending on the investors average, assessed precision matric of the distribution of the firms end-of-period cash flow (Lambert, et al., 2012).

Information asymmetry in real estate markets leads to higher costs and a reduction of returns (McAllister & Nanda, 2016). In real estate two types of information asymmetry can be found. First, sellers are likely to possess superior information on the current market conditions, since they are better informed about the local economy, social dynamics, governmental regulations and environmental considerations that may have an affect on the property. Second, sellers have more knowledge on the building characteristics and quality of the building than a purchaser (Milgrom & Stockey, 1982). Building characteristics have a large impact on the value of a building as these influence the rental rates of a building. Rental rates in low-end office buildings differ largely from high-end offices (Chau & Wong, 2015).

In markets with imperfect information, the use of information intermediaries can be economically beneficial (Milgrom & Stockey, 1982). These intermediaries can help in mitigating lack of information and eliminating behaviour biases (Milgrom & Stockey, 1982). The research of Chan (1983) focussed on the theory of positive search costs in information asymmetries. According to his research having (access to) information is especially difficult in the real estate market because of its illiquidity (Chan, 1983).

The function of a real estate broker is to act on behalf of an investor, which means that the broker should have absolute loyalty and obedience to the investor (Gibson, et al., 1983; Webster & Hetrick, 1983). It is expected that purchasers and sellers who pay for broker services are faced with lower investment prices and mitigated information asymmetries, however in practice, it seems that brokers actually do not always act in favour of the seller, nor the purchaser (Levit & Syverson, 2008; Ling, et al., 2016). According to research by Levit & Syverson (2008) and Ling et al. (2016) brokers do not ease the information asymmetry. Especially in highly illiquid markets the use of a broker actually increases the information asymmetry. This increase in asymmetry is the effect of the incentive for brokers to convince sellers to sell the property too quickly and therefore too cheap and convincing purchasers to search less and buy quicker (Levit & Syverson, 2008; Ling, et al., 2016).

Information asymmetry results from this information difference between seller and broker and between purchaser and broker (Levit & Syverson, 2008; Ling, et al., 2016). This is also seen in the research of Levit & Syverson (2008) where price premiums are found for the use of a broker on the private residential market. The use of a real estate broker as an intermediary results in an increase in the acquisition prices of premises and a decrease in selling prices. Research found a price increase for purchasers and a price decrease for sellers of 3% - 8% (Levit & Syverson, 2008). Ling et al. (2016) also researched the effect of the use of a broker on the commercial real estate market. In their research they found that average transaction prices are faced with a price premium up to 7.7%. The research of Ling et al (2016) showed the highest price premiums for the office sector (7.7%), while price premiums for the use of a broker for the industrial sector only amounted to 3.17% and for multi-family to 3.9%.

For the price premiums associated with the use of a broker during a real estate transaction three causes can be identified (Garmaise & Moskowitz, 2004). These premiums are possible due to the information asymmetry between seller and broker, purchaser and broker, and finally between seller and purchaser (Ling, et al., 2016; Levit & Syverson, 2008). First, in 6.9% of the transactions brokers act in their own interest, and not in the purchaser's (Garmaise & Moskowitz, 2004). Secondly, real estate brokers are compensated by a commission for their services being a percentage of the sale price, which encourages brokers to let investors pay too high transaction prices for their purchases (Garmaise & Moskowitz, 2004). Lastly, there are also cases where a purchasing broker is a subagent of the selling broker, therefore the broker has a fiduciary responsibility to the selling party, again resulting in a higher purchase price (Garmaise & Moskowitz, 2004).

Research by Milgrom & Stockey (1982) shows that uninformed brokers avoid to trade with informed counterparts. This leads to limited market participation which implies further decrease of their information level (Milgrom & Stockey, 1982). Next to that, Milgrom & Stockey (1982) also stated that informed brokers are more likely to sell to other informed brokers.

This implies that the market share of a broker also influences the level of information asymmetry. Brokers with a higher market share are often better informed than brokers with a lower market share (Milgrom & Stockey, 1982). This is fostered by the fact that better informed agents (with a higher market share) often withhold to trade with less informed agents resulting in information asymmetries (Milgrom & Stockey, 1982).

Previous research on how the use of a broker can increase or decrease information asymmetry leads to two hypotheses – assuming that increase or decrease of information asymmetry can be seen in the change of transaction prices provoked by the use of a broker. These hypotheses will be tested for the Netherlands as well as - using a subsample of the dataset - for Amsterdam. Moreover, sensitivity analyses are conducted on additional subsamples to check the findings. The hypotheses clarify the research question "How does the use of a broker during an office transaction influence the transaction price?"

Hypothesis 1:

H0: There *is no relation* between the use of a broker and the transaction prices per square meter for office transactions in the Netherlands.

H1 = There *is a relation* between the use of a broker and the transaction prices per square meter for office transactions in the Netherlands.

Hypothesis 2:

H0: There *is no relation* between the market share of a broker and the transaction prices per square meter for office transactions in the Netherlands.

H1: There *is a relation* between the market share of a broker and the transaction prices per square meter for office transactions in the Netherlands.

# 3 METHODOLOGY AND DATA

This section presents the methodology used in this research and the empirical model. The first part of this section presents the two models that are used: a hedonic regression model and a spatiotemporal model. In the second part a description of the dataset is given.

## 3.1 Empirical models

The research uses two model a hedonic regression and a STAR model. The hedonic regression generates a baseline analysis, the STAR model is included because it captures the local structure of the market by "predicting" the value of transactions more specifically. Both models will be applied to capture the effects of the use of a broker in the market for office investments.

The hedonic analysis found its origin in the application of agricultural land prices (Haas, 1922) and the automotive industry (Colwell & Dilmore, 1999). The first one to apply the hedonic model in a microeconomic context was Rosen (1974). In his research he showed that prices of goods are outcomes of the confrontation of supply and demand (Rosen, 1974). Nowadays the hedonic regression is a well-known statistical analysis that is often used in real estate research (Nappi-Choulet, et al., 2007). The model is primarily used by the private residential sector, but has also increasingly become more common in other sectors such as the office sector, where it is often used to determine office rents (Brennan, et al., 1984; Mills, 1992; Dunse & Jones, 1998; Nagai, et al., 2000; Nappi-Choulet, et al., 2007). The hedonic regression model can also be used for transaction prices; however, this is used less often (Nappi-Choulet, et al., 2007). The main reason for this is that transaction data often are confidential and difficult to get access to (Nappi-Choulet, et al., 2007; Downs & Slade, 1999).

The second model used in this research is a spatiotemporal auto regression, often referred to as the STAR model (Pace, et al., 1998). The STAR model is included in this research, since it captures the local structure of the market by modelling both space and time (Pace, et al., 1998). The STAR model uses information about nearby, recently sold properties to predict the value for a given property (Pace, et al., 1998). Instead of capturing the effect or regions by separate parameters, the STAR model assumes that nearby properties (seen as comparables) have a similar relation to the observations across the entire sample (Pace, et al., 1998).

The STAR model captures that current transaction values are influenced by previous nearby transactions (Pace, et al., 1998). To determine this "spill-over" effect a W matrix is constructed (Pace, et al., 1998). The W matrix is generated by the combination of a S matrix (space) and a T matrix (time) (Pace, et al., 1998). In order to include only previously sold transactions, the transaction that have occurred before the targeted transaction period are given non-zero values. This can be achieved by ordering the transactions from old to new (Pace, et al., 1998). The matrices S and T are stochastic matrices; which are standardized and can only be interpreted as linear filters (Anselin & Hudak, 1988; Davidson & MacKinnon, 1993).

In the research the dependent variable is the transaction price per square meter, which is transformed into a logarithm. There are multiple independent variables; of which several of them are relevant to answer the research question. The first independent variable of interest is a dummy variable which interprets whether a purchaser uses a broker or not. The second variable of interest is the market share of the broker. In this research the market share of the broker is determined by the number of the broker's transactions found in the dataset, taking into account both selling and purchasing activities. The market share of a broker is only considered when a broker is used, therefore it is an interaction term between the use of a broker and the market share of that broker. This research uses two separate regressions and two separate STAR models, the first ones addressing the use of a broker, the second ones the market share of a broker. This is necessary, because the market share of a broker and the use of a broker have turned out to be highly correlated. Next to that, several control variables are included to mitigate the effects of building specific and transaction specific characteristics.

The construction of the formulas will be described below. The first formula is the hedonic model - a multiple regression - that is defined as follows:

$$Ln(Pricesqm) = \propto + ß_1 B + ß_3 A + ß_4 SQM + \gamma_x TI + ß_5 IC + \theta_t Y_t + \varepsilon t \qquad (1)$$

$$Ln(Pricesqm) = \propto + ß_2 MS + ß_3 A + ß_4 SQM + \gamma_x TI + ß_5 IC + \theta_t Y_t + \varepsilon t \qquad (2)$$

The dependent variable is the logarithm of the transaction price per square meter and is called LN(Pricesqm). The residual graph can be found in Appendix 1 and shows a normal distribution. ∝ refers to the constant variable and εt to the error term. First, the relevant independent variables are discussed and afterwards the control variables will be explained: $B$ refers to a dummy variable for the use of a broker during a purchase, whereas the use of no broker is the reference variable. The use of a broker is not mandatory and even not frequent (in the dataset only 35% of the transactions occurred with a purchasing broker). Variable $MS$ is used for the market share of a broker. The variable $A$ shows the age of the building, determined by the years since the age of construction; renovations and redevelopments are not taken into account. $SQM$ is the variable for the size in square meters of the office building. $TI$ is used for the different types of investors: developer, government, institution, non-profit, pooled fund, private fund, propco and REIT, developer being the reference variable. $IC$ is the variable that refers to different investment categories of the total transaction volume in million euros; these categories are < € 5, € 5 – € 10, € 10 – € 25, € 25 – € 50, € 50 – € 100, > € 100, < € 5 being the reference category. $Y_t$ represents the year dummies, the years ranging from 2000-2017, 2000 being the reference year.

The second model is the STAR model including the spatiotemporal effect. This is defined as follows:

$$Ln(Pricesqm) = \propto + Z\theta + ß_1 B + ß_3 A + ß_4 SQM + + ß_6 IC + \theta_t Y_t + \varepsilon t \quad (3)$$

$$Ln(Pricesqm) = \propto + Z\theta + ß_2 MS + ß_3 A + ß_4 SQM + + ß_6 IC + \theta_t Y_t + \varepsilon t \quad (4)$$

The content of the model is the same as in the hedonic models, however the spatiotemporal effect is included in this model. The spatiotemporal effect is referred to as $Z\theta$. The spatiotemporal effect is found by giving weights to the five closest buildings that have seen a transaction before the targeted transaction. In order to include only the transactions that have occurred before the date of the transactions, the transactions are sorted and numbered from old to new, this to make sure that the transactions that have occurred afterwards do not show effect. The steps to determine this spatiotemporal effect can be found in appendix 5.

An overview of the independent variables can be found in table 1. This table includes the separate independent variables, the type of variable and a short description of the variable. The control variables are all of significance for academic research.

*Table 1: Overview of variables*

| Variable | Type of variable | Description |
|---|---|---|
| *Dependent variable* | | |
| Price per sq m | Logarithm | The logarithm of the transaction price per sq m in euro |
| *Independent variables* | | |
| Broker | Dummy variable | The use of a broker or not |
| Market share broker | Percentage | This variable is intended to address the experience of a broker. It is calculated by the number of the broker's transactions in the dataset. Both purchasing and selling activities were used to determine the broker's market share. The market share is only considered in the analyses, if the broker has been used. |
| Spatiotemporal effect | | The spatiotemporal effect is only taken into account in the STAR model. This will correct for neighbourhood and time effects. It is an autoregressive model and will be computed from the data (Pace, et al., 1998). |
| *Control variables* | | |
| Surface | Logarithm | The gross lettable area of a building. A building with a larger surface often has lower transaction prices per square meter (Ling, et al., 2016; Mills, 1992; Nappi-Choulet, et al., 2007). The surface has been transformed into a logarithm. The histogram can be found in Appendix 3. |
| Age building | Logarithm | The age of a building. The age is calculated relating to the building year; redevelopments and renovations are not considered. Older buildings generally are paired with lower transaction prices, except for historical buildings (Nappi-Choulet, et al., 2007; Mills, 1992; Ling, et al., 2016; Fuerst, 2007; Dunse & Jones, 1998; Clapp, 1980). The age has been transformed into a logarithm to come close to a normal distribution of the residuals. The residual histogram can be found in Appendix 2 |
| Investor type | Categorical | Different types of investors. The types of investors are: developer, government, institution, non-profit, pooled fund, private investor, propco, REIT (Bokhari & Geltner, 2011). |
| Investment category | Categorical | The investment category shows the size of the total investment in categories. The categories are <€ 5 million, € 5 – € 10 million, € 10 - €25 million, € 25 - € 50 million, € 50 - € 100 million and > € 100 million. |
| Transaction year | Dummy | The years are transformed into dummy variables for each separate transaction year. The years range from 2000 to 2017. |

### 3.2 Dataset and variables

The dataset used for this research has been obtained from Jones Lang LaSalle (JLL). The dataset consists of transactions larger than € 1,000,000 during the period 2000-2017 from the JLL investment database. JLL combines several sources to create their own database. This database consist of data purchased from PropertNL and from Real Capital Analytics. Next to that these data sources are complemented by data from JLL and other large broker firms (such as Cushman & Wakefield, Savills and Colliers). The transactions are then validated and enriched by both Research & Strategy and Capital Markets departments from JLL. This database is covering an estimated 90% of all transactions in this period, with recent data being more detailed than data dating from 2000.

The dataset of this research includes details regarding location, building characteristics, date of transaction, sale price, investment type, purchaser and seller characteristics and finally the purchaser and seller broker. It is only for a very limited number of transactions that the dataset contains information on yields and rents, due to the confidentiality of this information. Therefore, this data is not included in this research.

For the purpose of this research the dataset had to be optimized. This has been done in several steps. First of all, transactions that are part of a portfolio transaction have been filtered out. This had to be done, since transactions which are part of a portfolio lack information on location and sale price of the individual properties. Portfolio transaction premium and/or discounts are therefore also excluded. Secondly, transactions with data missing information on sale price, location and purchaser have been discarded. Finally, data of transactions without information on the year of construction and/or the surface of the building have been enriched with data from Basisregistratie Adressen en Gebouwen (BAG) (Kadaster, 2018). This optimization resulted in a total dataset of 3,133 transactions. Figure 1 shows the difference between the average transaction prices for office investment with and without the use of a purchase broker. Overall the figure shows no clear distinction between these two; only during short periods strong differences have been registered. Over the entire period the average transaction price for investors not using a broker amounts to € 2,122, for transactions that have used a broker the average amounts to € 2,199. In order to understand this difference due to the use of a broker, a statistical analysis (a hedonic regression and a STAR model) will be performed, whilst correcting for additional factors.

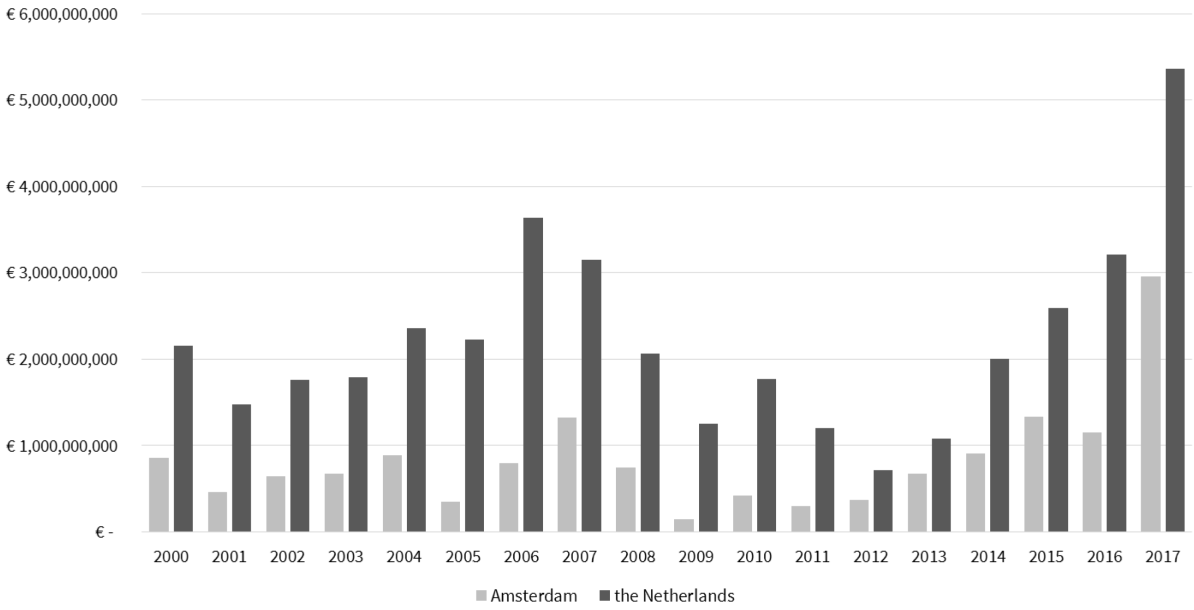


*Figure 1: Total transaction volumes in Amsterdam and the Netherlands per year*

## 3.3 Descriptive statistics

Table 2 provides an overview of the descriptive statistics of the dependent, independent, control and interaction variables of the entire dataset. In the dataset, most of the transactions have occurred without the use of a broker. However, the share of foreign purchasers using a broker is higher. Almost half of the foreign purchasers have used a broker for their transaction, in Amsterdam this percentage is a bit lower. The most active type of purchaser have been private funds (60.4%), whereas in the Amsterdam region propco's have also accounted for a large part of the transactions (20.5%).

*Table 2: Descriptive statistics*

| | The Netherlands | | | Amsterdam | | |
|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **Standard deviation** | **Proportion of Sample** | **Mean** | **Standard deviation** | **Proportion of Sample** |
| *Dependent variable* | | | | | | |
| LNPricesqm | 7.41 | 0.74 | 3133 | 7.81 | 0.71 | 615 |
| *Independent variables* | | | | | | |
| Broker yes | - | - | 35.3% | - | - | 38.4% |
| Market share broker | 1.09 | 2.6 | | 1.20 | 2.56 | - |
| *Control variables* | | | | | | |
| LNSurface | 8.04 | 1.18 | - | 8.34 | 1.33 | |
| LNAge | 3.52 | 0.94 | - | 3.77 | 1.23 | |
| Developer | - | - | 4.8% | - | - | 3.7% |
| Government | - | - | 0.6% | - | - | 0.5% |
| Institution | - | - | 5.0% | - | - | 6.5% |
| Non-profit | - | - | 1.8% | - | - | 1.3% |
| Pooled fund | - | - | 7.9% | - | - | 13.0% |
| Private fund | - | - | 60.4% | - | - | 52.5% |
| Propco | - | - | 17.1% | - | - | 20.5% |
| < € 5 million | - | - | 56.1% | - | - | 33.2% |
| € 5 - € 10 million | - | - | 16.2% | - | - | 17.2% |
| € 10 - € 25 million | - | - | 14.3% | - | - | 21.6% |
| € 25 - € 50 million | - | - | 7.5% | - | - | 13.3% |
| € 50 - € 100 million | - | - | 4.3% | - | - | 10.1% |
| > € 100 million | - | - | 1.6% | - | - | 4.6% |
| REIT | - | - | 2.5% | - | - | 2.3% |
| 2000 | - | - | 4.5% | - | - | 4.6% |
| 2001 | - | - | 5.5% | - | - | 4.7% |
| 2002 | - | - | 5.4% | - | - | 3.7% |
| 2003 | - | - | 3.7% | - | - | 2.6% |
| 2004 | - | - | 5.3% | - | - | 6.0% |
| 2005 | - | - | 5.5% | - | - | 4.6% |
| 2006 | - | - | 7.2% | - | - | 4.6% |
| 2007 | - | - | 6.9% | - | - | 5.9% |
| 2008 | - | - | 6.1% | - | - | 4.4% |
| 2009 | - | - | 4.3% | - | - | 2.6% |
| 2010 | - | - | 4.0% | - | - | 3.1% |
| 2011 | - | - | 3.5% | - | - | 2.4% |
| 2012 | - | - | 2.3% | - | - | 2.1% |
| 2013 | - | - | 2.6% | - | - | 3.9% |
| 2014 | - | - | 4.2% | - | - | 6.3% |
| 2015 | - | - | 7.9% | - | - | 13.7% |
| 2016 | - | - | 9.6% | - | - | 11.4% |
| 2017 | - | - | 11.4% | - | - | 13.5% |

In order to include a linear regression (such as a hedonic regression) there are six OLS assumptions that has to be checked before a regression can be performed (Brooks & Tsolacos, 2010). The first assumption states that there should be a linear relationship between the dependent and each of the independent variables (Brooks & Tsolacos, 2010). The test result show (appendix 4) that a linear relationship between the variables is in place. According to the second assumption the data needs to show homoscedasticity, variances need to be constant (Brooks & Tsolacos, 2010) which can be tested via the Breuch-Pangan/ Cook-Weisberg test. The test result from this assumption show slight heteroscedastic result (appendix 4). This heteroscedasticity can be overcome by using the White's robust standard errors (larger than normal standard errors). The third assumption states that there should be no multicollinearity. Multicollinearity occurs when two or more independent variables correlate with each other (Brooks & Tsolacos, 2010). This assumption does not come forward according to the correlation matrix (appendix 4). The fourth assumption states that the covariance between errors have to be zero (Brooks & Tsolacos, 2010). To overcome this issue of autocorrelation, variables over time are included. The fifth assumption states that there should be no significant outliers (Brooks & Tsolacos, 2010). This is tested via the display of the boxplot (appendix 4). Significant outliers where identified and removed from the dataset. The sixth and final assumption states that the residuals need to be normally distributed (Brooks & Tsolacos, 2010). This is the case as shown in appendix 4.

# 4 RESULTS

This chapter presents the results of this research. Model I and model II are hedonic regressions, model III and model IV are STAR models. First the results for both model I and model II will be discussed, afterwards model III and model IV. For both models, two separate models have been created, one showing the general impact of the use of a broker, the other model the specific impact of the market share of the used broker. Due to the high correlation between the use of a broker and the market share of a broker, these two separate models have been created. The market share of a broker is only considered, when he has been used.

The models I – IV show the results for the entire dataset (the Netherlands). Afterwards the results for the subsample of Amsterdam are presented in models V – Model VIII. Finally, a sensitivity check will be conducted for different time periods as well as different investment categories.

## 4.1 The Netherlands

The results from the four models for the Netherlands can be found in table 3. In all models the dependent variable is the transaction price per square meter. Since this transaction price per square meter is transformed into a natural logarithm, the coefficients can be interpreted as percentage change. In the third and fourth model a STAR model is used, where time and distance are used to calculate the spillover effect on the transaction prices. Model I - model IV the dependent variable is explained by 79% by the variation of the independent variables. The four models will be discussed separately; afterwards, a comparison between the models will be made.

In model I the coefficient (use of a broker or not) is positive, and is significant at a 1% level. The coefficient shows that the use of a broker leads to a price premium of 4.0% in comparison to transactions where no broker is used. This justifies the rejection of the first null hypothesis that stated that there is no relation between the use of a broker and the transaction prices per square meter for office transactions in the Netherlands.

This finding is in line with previous research. Previous research has also found price premiums for the use of a broker. Levit & Syverson, 2008, however, report higher price premiums amounting to 3% - 10%. The results are also in line with previous research by Ling et al. (2016). In his research they focus on different sectors in the commercial real estate market, found that transaction prices see an increase of 3% - 8% due to the use of a broker - the highest increases in transaction prices are seen in the office market (8%) (Ling, et al., 2016). These relatively higher price premiums found by Ling et al. (2016) may be due to the fact that these authors research total transaction prices, whereas this research focuses on transaction prices per square meter. Next to that, Ling et al. (2016) use control variables that differ from those used in this research.

The price premiums due to the use of a broker can be attributed to different causes. A first possible explanation is that according to Levit & Syverson (2008) and Ling et al. (2016) brokers convince purchasers to search less and buy properties too quickly, therefore resulting in price premiums. Next to that, another explanation could be the fact that brokers are encouraged to generate higher transaction prices, since the fee received is a percentage of these transaction prices (Garmaise & Moskowitz, 2004).

Model II finds that also the involvement of brokers with a higher market share (i.e. brokers with more experience) results in an increase of transaction prices per square meter. According to the findings of model II the transaction price per square meter will increase with a 0.6% per percentage increase of the broker's market share. This result is significant at a 5% level. Resulting in the rejection of the second null hypothesis: there is no relation between the market share of a broker and the transaction prices per square meter for office transactions in the Netherlands. In the used dataset the highest market share of a broker is found at 13%. According to the result from model II, a market share of 13% will result in a price premium of 7.8%.

As the theory states, more experienced intermediaries often have higher levels of information, superior to the information of less experienced brokers. Therefore the brokers could reduce information asymmetries by transferring their information to the purchaser (Milgrom & Stockey, 1982; Chan, 1983). According to the results, the higher level of market share actually results in increasing transaction prices per square meter. A possible explanation for this price premium is that investors in general might be willing to pay more, because they expect more experienced brokers to deliver better service.

The other variables of the research are used as control variables. The most striking result is shown by the different investment categories. These investment categories all show significant coefficients and result in large changes in transaction prices per square meter. The largest effect on the transaction price per square meter is found for the investment category > € 100 million. This results in an increase of the transaction price per square meter of 350%. Several of these categories are researched in more depth in the sensitivity analyses to see whether differences within these categories come forward.

The third and fourth model (STAR-model) are similar to the first and second, however both include a spatiotemporal effect next to the other variables. The spatiotemporal variable captures the local structure of the market (Pace, et al., 1998). The results of model III and model IV show a slight change compared to model I and model II as a result of this inclusion of this spatiotemporal effect: the coefficient for the use of a broker and for the market share of a broker decrease slightly. The spatiotemporal effect explains 9.5% of the variation in the transaction price per square meter for both model III and model IV.

The effect of the use of a broker is slightly smaller in model III and comes down to 3.6%. The effect of the market share of a broker remains more or less the same. In Model II the latter amounts to 0.6% and in model IV to 0.5% per percentage increase in market share. The measured impact of the use of a broker is significant on a 1% level, that of the market share of a broker is significant on a 5% level. Furthermore, the control variables also see small changes in coefficients, but no signs are changed and effects remain similar to those in the first models. Therefore, the results of model III and model IV underpin the rejection of the first and the second null hypothesis.

The regression model and the STAR model show slightly different results. The decrease in coefficients in the STAR model is the result of the inclusion of the spatiotemporal effect. Due to the inclusion of this spatiotemporal effect the impact of properties in the neighbourhood are included and therefore explain changes in prices. Therefore it could be said that the results of model III and model IV are more accurate.

*Table 3: Results the Netherlands*

| | Model I: Hedonic regression NL broker | | Model II : Hedonic regression NL market share broker | | Model III: STAR model NL broker | | Model IV: STAR model NL market share broker | |
|---|---|---|---|---|---|---|---|---|
| Observations | 3,130 | | 3,130 | | 3,130 | | 3,130 | |
| R square | 0.7886 | | 0.7884 | | | | | |
| Adjusted R-square | 0.7864 | | 0.7862 | | | | | |
| Pseudo R square | | | | | 0.7905 | | 0.7903 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 13.1723** | 0.0855 | 13.1725** | 0.0856 | 12.3853** | 0.1500 | 12.3889** | 0.1500 |
| Broker | 0.0400** | 0.0136 | - | - | 0.0358** | 0.0134 | - | - |
| Market share broker | - | - | 0.0060* | 0.0024 | - | - | 0.0053* | 0.0023 |
| Spatiotemporal | - | - | - | - | 0.0951** | 0.0150 | 0.0947** | 0.0150 |
| LNAge | 0.0060 | 0.0070 | 0.0058 | 0.0070 | 0.0012 | 0.0069 | 0.0010 | 0.0069 |
| LNSurface | -0.8014** | 0.0085 | -0.8016** | 0.0085 | -0.7904** | 0.0085 | -0.7906** | 0.0086 |
| Government | 0.0490 | 0.0857 | 0.0492 | 0.0857 | 0.0417 | 0.0842 | 0.0420 | 0.0842 |
| Institution | 0.0543 | 0.0403 | 0.0541 | 0.0403 | 0.0450 | 0.0396 | 0.0448 | 0.0396 |
| Non-profit | -0.0225 | 0.0533 | -0.0175 | 0.0533 | -0.0294 | 0.0524 | -0.0249 | 0.0524 |
| Pooled fund | 0.0715 | 0.0365 | 0.0720* | 0.0366 | 0.0604 | 0.0359 | 0.0610 | 0.0359 |
| Private fund | -0.0654 | 0.0294 | -0.0636* | 0.0295 | -0.0706 | 0.0289 | -0.0690 | 0.0289 |
| Propco | 0.0425 | 0.0329 | 0.0469 | 0.0329 | 0.0376 | 0.0323 | 0.0416 | 0.0323 |
| REIT | 0.0936 | 0.0486 | 0.0929 | 0.0486 | 0.0824 | 0.0477 | 0.0818 | 0.0478 |
| € 5 - € 10 million | 0.9564** | 0.0197 | 0.9563** | 0.0197 | 0.9374** | 0.0196 | 0.9374** | 0.0196 |
| € 10 - € 25 million | 1.6165** | 0.0237 | 1.6164** | 0.0237 | 1.5849** | 0.0238 | 1.5851** | 0.0238 |
| € 25 - € 50 million | 2.2714** | 0.0312 | 2.2714** | 0.0313 | 2.2193** | 0.0318 | 2.2196** | 0.0318 |
| € 50 - € 100 million | 2.8624** | 0.0392 | 2.8624** | 0.0393 | 2.8026** | 0.0397 | 2.8029** | 0.0397 |
| > € 100 million | 3.5186** | 0.0577 | 3.5217** | 0.0577 | 3.4419** | 0.0579 | 3.4452** | 0.0579 |
| 2001 | -0.0212 | 0.0389 | -0.0207 | 0.0389 | 0.0020 | 0.0384 | 0.0024 | 0.0384 |
| 2002 | -0.0763 | 0.0394 | -0.0692 | 0.0393 | -0.0507 | 0.0389 | -0.0444 | 0.0388 |
| 2003 | -0.0670 | 0.0432 | -0.0587 | 0.0430 | -0.0345 | 0.0428 | -0.0271 | 0.0426 |
| 2004 | -0.0826* | 0.0396 | -0.0762 | 0.0394 | -0.0521 | 0.0392 | -0.0465 | 0.0390 |
| 2005 | -0.0710 | 0.0395 | -0.0622 | 0.0392 | -0.0406 | 0.0391 | -0.0328 | 0.0387 |
| 2006 | -0.1014** | 0.0376 | -0.0908* | 0.0371 | -0.0719 | 0.0372 | -0.0624 | 0.0368 |
| 2007 | -0.0247 | 0.0377 | -0.0155 | 0.0375 | 0.0072 | 0.0374 | 0.0154 | 0.0371 |
| 2008 | -0.0619 | 0.0386 | -0.0542 | 0.0384 | -0.0321 | 0.0382 | -0.0253 | 0.0380 |
| 2009 | -0.0154 | 0.0420 | -0.0034 | 0.0416 | 0.0057 | 0.0414 | 0.0164 | 0.0409 |
| 2010 | -0.0132 | 0.0426 | -0.0035 | 0.0423 | 0.0064 | 0.0419 | 0.0150 | 0.0417 |
| 2011 | -0.0577 | 0.0440 | -0.0471 | 0.0437 | -0.0301 | 0.0434 | -0.0206 | 0.0431 |
| 2012 | -0.0656 | 0.0503 | -0.0544 | 0.0501 | -0.0503 | 0.0495 | -0.0404 | 0.0492 |
| 2013 | -0.0767 | 0.0477 | -0.0692 | 0.0475 | -0.0705 | 0.0468 | -0.0638 | 0.0467 |
| 2014 | -0.1466** | 0.0419 | -0.1423** | 0.0418 | -0.1255** | 0.0413 | -0.1217** | 0.0412 |
| 2015 | -0.1421** | 0.0367 | -0.1382** | 0.0366 | -0.1276** | 0.0361 | -0.1241** | 0.0360 |
| 2016 | -0.0870* | 0.0358 | -0.0790* | 0.0355 | -0.0652 | 0.0354 | -0.0581 | 0.0350 |
| 2017 | -0.0604 | 0.0350 | -0.0490 | 0.0346 | -0.0335 | 0.0346 | -0.0234 | 0.0342 |

* significant at p 0.05, ** significant at p 0.01

## 4.2 Amsterdam

The hedonic model and the STAR model are also executed for a subsample of Amsterdam. The subsample of Amsterdam is included, since Amsterdam is the most liquid market in the Netherlands. 37% of the transactions of the entire dataset have occurred in Amsterdam. Next to that, Amsterdam is seen as a relative transparent market (JLL, 2016), and therefor is an interesting touchstone to see if other results come forward. Amsterdam is included to create a better understanding if different results come forward when concentrating on a subsample.

For the subsample of Amsterdam the same models as for the Netherlands are conducted. First the hedonic regression is performed in model V and model VI for baseline results. Second, the STAR model is executed in model VII and model VIII to include the local structure of the market (Pace, et al., 1998). The results of the models for the subsample can be found in table 4.

In all models (model V – model VIII) 84% of the dependent variable is explained by the variation of the independent variables. The coefficient for the use of a broker is similar to the results found in the models I and III. According to model V the price premium for the use of a broker is 3.9% for model V, for model VII this price premium amounts to 3.7%. These results only differ 0.1% from the results from model I and model III, which shows an effect of respectively 4.0% and 3.6%. The results of model V and model VII turn out to be in line with the previously found results. However, all results concerning the use of a broker are not significant.

The market share of a broker shows stronger effects in Amsterdam amounting to 0.9% in both model VI and model VIII, whereas the effect of the market share for the Netherlands only amounted to 0.6% and 0.5%. However, both the coefficients for the use of a broker and the market share of a broker for the subsample of Amsterdam are not significant. The higher impact of the broker's market share in Amsterdam compared to the Netherlands could be explained by the fact that in Amsterdam on average more brokers with a higher market share are used. This also came forward in the descriptive statistics of table 2. The spatiotemporal effects found in models VII and model VIII both show a 6.7% impact of the local structure of the market on the transaction price per square meter. Since the subsample is based on a smaller location, it is not surprising that the impact is lower than the one found in model III and model IV. However, there are still large differences between assets in different regions of Amsterdam. The Amsterdam Zuidas is seen as the best office location in the Netherlands, whereas office locations such as South West are ranked as the 40$^{th}$ office location of the Netherlands (JLL, 2016). Since the spatiotemporal effect is still visible in Amsterdam, these local variations are accounted for. The different investment categories also show strong impact in Amsterdam; therefore they are relevant for the sensitivity analysis. Next to that, years 2004 and 2015 both show significant results, the years both show a decrease in the transaction prices compared to 2000.

*Table 4: Results Amsterdam*

| | **Model V: Hedonic regression Amsterdam broker** | | **Model VI: Hedonic regression Amsterdam market share broker** | | **Model VII: STAR model Amsterdam broker** | | **Model VIII: STAR model Amsterdam market share broker** | |
|---|---|---|---|---|---|---|---|---|
| Observations | 614 | | 614 | | 614 | | 614 | |
| R square | 0.8424 | | 0.8426 | | | | | |
| Adjusted R-square | 0.8337 | | 0.8430 | | | | | |
| Pseudo R square | | | | | 0.8432 | | 0.8434 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 13.6909** | 0.1621 | 13.7023** | 0.1621 | 13.0997** | 0.2645 | 13.1159** | 0.2642 |
| Broker | 0.0392 | 0.0263 | - | - | 0.0370 | 0.0254 | - | - |
| Market share broker | - | - | 0.0088 | 0.0049 | - | - | 0.0087 | 0.0048 |
| Spatiotemporal | - | - | - | - | 0.0666 | 0.0240 | 0.0660** | 0.0240 |
| LNAge | 0.0122 | 0.0109 | 0.0126 | 0.0109 | 0.0111 | 0.0105 | 0.0116 | 0.0105 |
| LNSurface | -0.8517** | 0.0168 | -0.8538** | 0.0168 | -0.8413** | 0.0167 | -0.8434** | 0.0166 |
| Government | -0.1726 | 0.1821 | -0.1590 | 0.1820 | -0.1946 | 0.1761 | -0.1812 | 0.1761 |
| Institution | 0.0665 | 0.0781 | 0.0630 | 0.0781 | 0.0586 | 0.0756 | 0.0552 | 0.0756 |
| Non-profit | -0.0240 | 0.1227 | -0.0042 | 0.1226 | -0.0471 | 0.1189 | -0.0278 | 0.1188 |
| Pooled fund | 0.0524 | 0.0722 | 0.0561 | 0.0720 | 0.0411 | 0.0699 | 0.0445 | 0.0697 |
| Private fund | -0.0232 | 0.0635 | -0.0171 | 0.0633 | -0.0321 | 0.0614 | -0.0262 | 0.0613 |
| Propco | 0.0135 | 0.0687 | 0.0211 | 0.0685 | 0.0118 | 0.0664 | 0.0190 | 0.0662 |
| REIT | 0.0207 | 0.1004 | 0.0208 | 0.1003 | 0.0030 | 0.0972 | 0.0031 | 0.0971 |
| € 5 - € 10 million | 0.8760** | 0.0409 | 0.8729** | 0.0410 | 0.8679** | 0.0397 | 0.8649** | 0.0397 |
| € 10 - € 25 million | 1.5398** | 0.0466 | 1.5417** | 0.0465 | 1.5299** | 0.0452 | 1.5316** | 0.0450 |
| € 25 - € 50 million | 2.2358** | 0.0570 | 2.2400** | 0.0568 | 2.2095** | 0.0559 | 2.2136** | 0.0557 |
| € 50 - € 100 million | 2.8216** | 0.0687 | 2.8255** | 0.0683 | 2.7863** | 0.0676 | 2.7899** | 0.0672 |
| > € 100 million | 3.5596** | 0.0873 | 3.5647** | 0.0870 | 3.5141** | 0.0860 | 3.5192** | 0.0857 |
| 2001 | 0.0020 | 0.0777 | 0.0010 | 0.0776 | 0.0054 | 0.0751 | 0.0043 | 0.0750 |
| 2002 | -0.0659 | 0.0838 | -0.0644 | 0.0836 | -0.0661 | 0.0810 | -0.0649 | 0.0808 |
| 2003 | -0.1409 | 0.0928 | -0.1352 | 0.0922 | -0.1295 | 0.0898 | -0.1246 | 0.0892 |
| 2004 | -0.1890* | 0.0753 | -0.1914* | 0.0750 | -0.1810* | 0.0728 | -0.1841* | 0.0726 |
| 2005 | -0.1113 | 0.0807 | -0.1024 | 0.0793 | -0.0917 | 0.0784 | -0.0840 | 0.0769 |
| 2006 | -0.1270 | 0.0825 | -0.1194 | 0.0810 | -0.1159 | 0.0798 | -0.1095 | 0.0783 |
| 2007 | 0.0412 | 0.0756 | 0.0477 | 0.0750 | 0.0499 | 0.0731 | 0.0557 | 0.0726 |
| 2008 | -0.0485 | 0.0808 | -0.0394 | 0.0799 | -0.0447 | 0.0781 | -0.0365 | 0.0772 |
| 2009 | -0.0429 | 0.0950 | -0.0384 | 0.0944 | -0.0334 | 0.0919 | -0.0296 | 0.0913 |
| 2010 | -0.0620 | 0.0881 | -0.0610 | 0.0879 | -0.0679 | 0.0852 | -0.0672 | 0.0849 |
| 2011 | 0.0103 | 0.0943 | 0.0155 | 0.0937 | 0.0089 | 0.0911 | 0.0134 | 0.0906 |
| 2012 | -0.0880 | 0.1000 | -0.0768 | 0.0989 | -0.0971 | 0.0967 | -0.0869 | 0.0956 |
| 2013 | -0.0129 | 0.0835 | -0.0065 | 0.0825 | -0.0138 | 0.0807 | -0.0083 | 0.0798 |
| 2014 | -0.1210 | 0.0743 | -0.1203 | 0.0740 | -0.1211 | 0.0718 | -0.1209 | 0.0715 |
| 2015 | -0.1371* | 0.0666 | -0.1381* | 0.0662 | -0.1309* | 0.0644 | -0.1327* | 0.0641 |
| 2016 | -0.0227 | 0.0681 | -0.0234 | 0.0678 | -0.0106 | 0.0660 | -0.0119 | 0.0656 |
| 2017 | -0.0043 | 0.0666 | 0.0008 | 0.0658 | 0.0078 | 0.0645 | 0.0120 | 0.0637 |

** significant at p 0.05, ** significant at p 0.01*

## 4.3 Sensitivity analysis

In this section a sensitivity analysis is performed. A sensitivity analysis is necessary to show the different sources of uncertainty in the model. Input is linked to the uncertainty within the output of a model (Saltelli, 2002). The sensitivity analysis for this research is conducted on two different divisions.

First the time line is divided into two parts by the end of 2008 to see if there is a difference between the period before and after the global financial crisis. This division is made, as especially after the global financial crisis the transparency of the real estate market has increased in a rapid pace, further reinforced by to the progression of information technology.

Second a division is made between four different investment categories. This division is included, since the different investment categories show strong influence on transaction prices (see table 3). Identifying the effects of these different categories could give more insights in the impact of the use of a broker.

For both divisions the hedonic models and the STAR models are executed. First the division based on time is discussed, afterwards the division based on investment categories. In the discussion the different subsets are compared as well as to each other as to the results of the entire sample found in table 3.

In table 5 ad table 6 the results of division based on time are presented. Model IX – model XII show the results for the period 2000-2008, model XIII – model XVI for the period 2009-2017. The subsample of the period 2000-2008 consist of 1,570 transactions. The dependent variable of this sub-sample is explained for 72% by the variation of the independent variables**.** The subsample for the period 2009-2017 consists of 1,560 transactions. Model XIII – model XVI explain 83% of the variation in the dependent variable as a result of the variation of the independent variables. The spatiotemporal effects in model XI and model XII amount to 7.2%, in model XV and model XVI 8.3%.

The coefficient for the use of a broker shows a different trend. Whereas the price premium per square meter when using a broker for the period 2000-2008 amounted to 4.1% and 3.6%, the effect decreased in the period 2009-2017 to 3.6% and 3.2%. Compared to the results of table 3 both coefficients are lower; in the period after the crisis even more so. A possible explanation for this could be that over the years brokers have been more successful in mitigating information to a purchaser (Milgrom & Stockey, 1982). This might result in less high price premiums for the purchasers when they used a broker; however, the use of a broker still increased the transaction price per square meter. The results for the period 2000-2008 lead to the rejection of the first hypothesis that states there is no relation between the use of a broker and the transaction price per square meter for office transactions in the Netherlands. The second period does not give any significant results for this hypothesis.

The sensitivity analysis of the market share of a broker shows similar results to the results of the Netherlands. Investors using a broker with a higher market share are faced with price premiums of 0.6% - 0.7% per percentage increase of the market share in the period 2000-2008. For the period 2009-2017 this price premium amounts to 0.57% - 0.63% per percentage increase of the market share of the broker. Only the results for the period 2000-2008 are significant on a 5% level; therefore only these results justify to reject the null hypothesis that there is no relation between the market share of a broker and the transaction price per square meter for office investments in the Netherlands. Price premiums for a higher market share of a broker see a decrease over time. The results found for Amsterdam are slightly above this level, whilst the results for the Netherlands are slightly below this level.

*Table 5: Results for split time period 2000-2008*

| | **Model IX: Hedonic regression 2000-2008 broker** | | **Model X: Hedonic regression 2000-2008 market share broker** | | **Model XI: STAR model 2000-2008 broker** | | **Model XII: STAR model 2000-2008 market share broker** | |
|---|---|---|---|---|---|---|---|---|
| Observations | 1,570 | | 1,570 | | 1,570 | | 1,570 | |
| R square | 0.7144 | | 0.7144 | | | | | |
| Adjusted R-square | 0.7102 | | 0.7102 | | | | | |
| Pseudo R square | | | | | 0.7153 | | 0.7153 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 12.5363** | 0.1266 | 12.5313** | 0.1267 | 11.9052** | 0.2189 | 11.9001** | 0.2188 |
| Broker | 0.0408* | 0.0187 | - | - | 0.0363* | 0.0184 | - | - |
| Market share broker | - | | 0.0067* | 0.0031 | - | - | 0.0062* | 0.0030 |
| Spatiotemporal | - | | - | - | 0.0790** | 0.0225 | 0.0791** | 0.0225 |
| LNAge | -0.0050 | 0.0102 | -0.0049 | 0.0102 | -0.0089 | 0.0101 | -0.0088 | 0.0101 |
| LNSurface | -0.7115** | 0.0134 | -0.7107** | 0.0134 | -0.7061** | 0.0133 | -0.7054** | 0.0133 |
| Government | -0.0128 | 0.1207 | -0.0111 | 0.1207 | -0.0192 | 0.1188 | -0.0176 | 0.1188 |
| Institution | 0.0691 | 0.0529 | 0.0662 | 0.0529 | 0.0646 | 0.0521 | 0.0620 | 0.0521 |
| Non-profit | -0.0718 | 0.0823 | -0.0698 | 0.0823 | -0.0801 | 0.0809 | -0.0783 | 0.0809 |
| Pooled fund | 0.0403 | 0.0545 | 0.0360 | 0.0545 | 0.0388 | 0.0536 | 0.0349 | 0.0536 |
| Private fund | -0.0590 | 0.0457 | -0.0599 | 0.0457 | -0.0592 | 0.0449 | -0.0600 | 0.0449 |
| Propco | 0.0750 | 0.0476 | 0.0772 | 0.0476 | 0.0750 | 0.0469 | 0.0770 | 0.0468 |
| REIT | 0.1246* | 0.0621 | 0.1239** | 0.0621 | 0.1202* | 0.0611 | 0.1196* | 0.0611 |
| € 5 - € 10 million | 0.8550** | 0.0263 | 0.8544** | 0.0263 | 0.8426** | 0.0261 | 0.8420** | 0.0261 |
| € 10 - € 25 million | 1.4491** | 0.0323 | 1.4466** | 0.0323 | 1.4301** | 0.0322 | 1.4278** | 0.0322 |
| € 25 - € 50 million | 2.0309** | 0.0426 | 2.0263** | 0.0428 | 1.9982** | 0.0430 | 1.9938** | 0.0431 |
| € 50 - € 100 million | 2.5937** | 0.0555 | 2.59008* | 0.0556 | 2.5574** | 0.0556 | 2.5540** | 0.0556 |
| > € 100 million | 3.1227** | 0.0783 | 3.1196** | 0.0784 | 3.0774** | 0.0781 | 3.0744** | 0.0782 |
| 2001 | -0.0114 | 0.0363 | -0.0109 | 0.0363 | 0.0076 | 0.0361 | 0.0081 | 0.0361 |
| 2002 | -0.0558 | 0.0371 | -0.0484 | 0.0368 | -0.0354 | 0.0370 | -0.0288 | 0.0366 |
| 2003 | -0.0554 | 0.0405 | -0.0472 | 0.0401 | -0.0284 | 0.0406 | -0.0212 | 0.0401 |
| 2004 | -0.0560 | 0.0374 | -0.0500 | 0.0369 | -0.0313 | 0.0374 | -0.0262 | 0.0369 |
| 2005 | -0.0470 | 0.0374 | -0.0388 | 0.0367 | -0.0218 | 0.0375 | -0.0147 | 0.0368 |
| 2006 | -0.0711* | 0.0360 | -0.0609 | 0.0350 | -0.0473 | 0.0361 | -0.0386 | 0.0350 |
| 2007 | 0.0145 | 0.0358 | 0.0237 | 0.0352 | 0.0373 | 0.0358 | 0.0453 | 0.0352 |
| 2008 | -0.0177 | 0.0366 | -0.0101 | 0.0361 | 0.0061 | 0.0366 | 0.0127 | 0.0361 |

** significant at p 0.05, ** significant at p 0.01*

*Table 6: Results for split time period 2009-20017*

| | **Model XIII: Hedonic regression 2009-2017 broker** | | **Model XIV: Hedonic regression 2009-2017 market share broker** | | **Model XV: STAR model 2009-2017 broker** | | **Model XVI: STAR model 2009-2017 market share broker** | |
|---|---|---|---|---|---|---|---|---|
| Observations | 1,560 | | 1,560 | | 1,560 | | 1.560 | |
| R square | 0.8282 | | 0.8282 | | | | | |
| Adjusted R-square | 0.8256 | | 0.8256 | | | | | |
| Pseudo R square | | | | | 0.8306 | | 0.8305 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 13.4722** | 0.1081 | 13.4837** | 0.1078 | 12.7400** | 0.1832 | 12.7509** | 0.1832 |
| Broker | 0.0360 | 0.0196 | - | - | 0.0318 | 0.0192 | - | - |
| Market share broker | - | - | 0.0063 | 0.0036 | - | - | 0.0057 | 0.0035 |
| Spatiotemporal | - | - | - | - | 0.0837** | 0.0171 | 0.0836** | 0.0171 |
| LNAge | 0.0153 | 0.0095 | 0.0152 | 0.0095 | 0.0078 | 0.0094 | 0.0078 | 0.0094 |
| LNSurface | -0.8489** | 0.0111 | -0.8495** | 0.0111 | -0.8340** | 0.0113 | -0.8346** | 0.0113 |
| Government | 0.0610 | 0.1200 | 0.0576 | 0.1201 | 0.0611 | 0.1177 | 0.0578 | 0.1178 |
| Institution | 0.0012 | 0.0718 | 0.0023 | 0.0718 | -0.0125 | 0.0705 | -0.0114 | 0.0705 |
| Non-profit | 0.0131 | 0.0702 | 0.0193 | 0.0701 | 0.0146 | 0.0688 | 0.0201 | 0.0687 |
| Pooled fund | 0.0632 | 0.0501 | 0.0648 | 0.0501 | 0.0455 | 0.0493 | 0.0469 | 0.0492 |
| Private fund | -0.0765 | 0.0386 | -0.0737 | 0.0386 | -0.0840* | 0.0379 | -0.0815** | 0.0379 |
| Propco | -0.0136 | 0.0469 | -0.0085 | 0.0469 | -0.0257 | 0.0460 | -0.0211 | 0.0460 |
| REIT | 0.0096 | 0.0837 | 0.0039 | 0.0838 | -0.0087 | 0.0822 | -0.0139 | 0.0822 |
| € 5 - € 10 million | 1.0221** | 0.0290 | 1.0218** | 0.0290 | 1.0014** | 0.0287 | 1.0011** | 0.0288 |
| € 10 - € 25 million | 1.7284** | 0.0352 | 1.7291** | 0.0352 | 1.6906** | 0.0353 | 1.6911** | 0.0353 |
| € 25 - € 50 million | 2.4275** | 0.0471 | 2.4294** | 0.0471 | 2.3753** | 0.0474 | 2.3769** | 0.0474 |
| € 50 - € 100 million | 3.0111** | 0.0571 | 3.0106** | 0.0572 | 2.9520** | 0.0573 | 2.9513** | 0.0574 |
| > € 100 million | 3.7897** | 0.0855 | 3.7951** | 0.0853 | 3.7086** | 0.0855 | 3.7133** | 0.0853 |
| 2010 | 0.0014 | 0.0445 | -0.0005 | 0.0445 | 0.0289 | 0.0440 | 0.0272 | 0.0440 |
| 2011 | -0.0379 | 0.0460 | -0.0391 | 0.0460 | -0.0125 | 0.0454 | -0.0136 | 0.0454 |
| 2012 | -0.0543 | 0.0525 | -0.0549 | 0.0525 | -0.0219 | 0.0519 | -0.0224 | 0.0519 |
| 2013 | -0.0391 | 0.0504 | -0.0428 | 0.0503 | -0.0140 | 0.0497 | -0.0173 | 0.0496 |
| 2014 | -0.1207** | 0.0443 | -0.1274** | 0.0441 | -0.0862* | 0.0440 | -0.0922** | 0.0438 |
| 2015 | -0.1118** | 0.0388 | -0.1190** | 0.0386 | -0.0800* | 0.0386 | -0.0865** | 0.0384 |
| 2016 | -0.0561 | 0.0374 | -0.0600 | 0.0374 | -0.0120 | 0.0378 | -0.0155 | 0.0378 |
| 2017 | -0.0403 | 0.0365 | -0.0406 | 0.0365 | 0.0126 | 0.0374 | 0.0123 | 0.0374 |

** significant at p 0.05, ** significant at p 0.01*

Table 7 to table 10 show the results of the hedonic regression and the STAR model for different investment categories. The different investment categories of the total transaction volume are <€ 10 million, € 10 - € 50 million, € 50 - € 100 million and > € 100 million. In the first investment category 2,263 transactions occurred, in the investment category € 10 - € 50 million 681 transactions, 136 transactions occurred in the investment category € 50 - € 100 million, and finally, 50 transactions in the largest the investment category. Therefore the quality of the results for the larger investment categories is less accurate. When samples are smaller, less reliable results can come forward (Moore & McCabe, 2009).

For model XVII – XX the dependent variable - transaction price per square meter - is explained for 55% by the variance of the independent variables. For the investment category € 10 - € 50 million the dependent variable is explained for 57% (hedonic regression) and 59% (STAR) by the variance of the independent variables. For the investment category € 50 - € 100 million models XXV and XXVI show 90%, model XXVII 92%, and model XXVIII 60%. Lastly for the investment category > € 100 million the dependent variable is explained for 30% and 64% by the variation of the independent variables.

The analysis addressing the use of a broker shows different results. For the smallest investment category < € 10 million (model XVIII and model XIX) price premiums of 6.5% and 6.2% are seen, which are just above the results for the Netherlands (4.0% and 3.6%). Both coefficients in model XVIII and model XIX show significant results on a 1% level and therefore result in the rejection of the null hypothesis stating there is no relation between the use of a broker and the transaction price per square meter for office transactions in the Netherlands. Price premiums in the investment category € 10 million - € 50 million show a slightly lower effect of the use of a broker compared to the investment category < € 10 million. The price premiums related to the use of a broker in model XXI and model XXIII amount to 5.0% and 4.5%. The largest investment category of > € 100 million shows a strong impact of the use of brokers. According to model XXIX price premiums of 15.5% on the transaction price per square meter are paid when using a broker, according to model XXXI this price premium amounts to 7.0%. However, these results are not significant. Interestingly, the investment category € 50 million – € 100 million shows a decrease of prices in relationship to the use of a broker. In both models XXV and XXVII prices in average are 0.1% lower. However, both results are not significant, and since the sample only consists of a limited number of transactions, it is difficult to draw reliable conclusions from these results.

The analysis of the market share of a broker shows similar results in this sensitivity analysis as compared to the results for the Netherlands. Where the results of model I and III show price premiums of 0.6% and 0.5%, the results for the investment category < € 10 million show similar outcomes. Price premiums of 0.7% are seen in both models XVIII and XX. However, these results are not significant. The largest investment category (> € 100 million) shows the highest price premiums on the transaction prices per square meter for the market share of a broker. According to model XXX price premiums of 4.4% are paid, and according to model XXXII price premiums of 2.4% are paid. These price premiums are per percentage increase of the market share of a broker. Therefore, price premiums will increase even more, when the market share increases. Interestingly, for the investment category € 50 million - € 100 million a different result comes forward. In this category using brokers with a higher market share results in a decrease of the transaction price per square meter by 0.3% for model XXVII and a price premium of 0.1% for model XXVIII. Since the results of model XXVIII are significant on a 1% level, for model XXVIII not significant, in this investment category purchasers can expect lower prices due to the use of a broker with a higher market share. Finally in the investment category € 10 million - € 50 million price premiums of 0.1% are seen (model XXII and model XXIV). Both results are significant on a 1% level and lead to reject the null hypothesis stating that there is no relation between the market share of a broker and the transaction price per square meter for office transactions in the Netherlands.

Overall, the sensitivity analysis shows similar results to those of the Netherlands. All significant results lead to the rejection of both null hypotheses. Therefore, it could be said that the use of a broker and the market share of the broker has impact on the transaction price per square meter for office transactions in the Netherlands. However, some slight differences in the strength of this relationship is seen for different investment categories. Next to that, price premiums paid for the use of a broker before and after the global financial crisis are in general lower compared to the price premiums found in the Netherlands, with an additional decrease after 2008. Interestingly, for the investment category € 50 million - € 100 million the use of a broker results in lower prices, this result, however, not being significant.

*Table 7: Results on split investment category <€ 10 million*

| | **Model XVII: Hedonic regression <€10 mln broker** | | **Model XVIII: Hedonic regression <€10 mln market share broker** | | **Model XIX: STAR model <€10 mln broker** | | **Model XX: STAR model <€10 mln market share broker** | |
|---|---|---|---|---|---|---|---|---|
| Observations | 2,263 | | 2,263 | | 2,263 | | 2,263 | |
| R square | 0.5519 | | 0.5509 | | | | | |
| Adjusted R-square | 0.5465 | | 0.5455 | | | | | |
| Pseudo R square | | | | | 0.5504 | | 0.5493 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 11.7298** | 0.1379 | 11.7306** | 0.1381 | 11.0600** | 0.2867 | 11.0696** | 0.2873 |
| Broker | 0.0651** | 0.0240 | - | - | 0.0622** | 0.0236 | - | - |
| Market share broker | - | - | 0.0073 | 0.0045 | - | - | 0.0071 | 0.0044 |
| Spatiotemporal | - | - | - | - | 0.0842** | 0.0318 | 0.0831** | 0.0318 |
| LNAge | 0.0217 | 0.0122 | 0.0207 | 0.0122 | 0.0155 | 0.0123 | 0.0146 | 0.0123 |
| LNSurface | -0.5951** | 0.0125 | -0.5951** | 0.0125 | -0.5876** | 0.0126 | -0.5877** | 0.0126 |
| Government | 0.1248 | 0.1590 | 0.1422 | 0.1590 | 0.1216 | 0.1563 | 0.1382 | 0.1563 |
| Institution | 0.4110** | 0.0785 | 0.4085** | 0.0785 | 0.4001** | 0.0772 | 0.3979** | 0.0773 |
| Non-profit | -0.0465 | 0.0842 | -0.0372 | 0.0842 | -0.0451 | 0.0827 | -0.0363 | 0.0828 |
| Pooled fund | 0.2009** | 0.0705 | 0.2030** | 0.0706 | 0.1886** | 0.0694 | 0.1907** | 0.0695 |
| Private fund | -0.0905 | 0.0493 | -0.0872 | 0.0494 | -0.0940 | 0.0485 | -0.0908 | 0.0486 |
| Propco | 0.2395** | 0.0589 | 0.2444** | 0.0590 | 0.23450** | 0.0579 | 0.2398** | 0.0580 |
| REIT | 0.4089** | 0.0923 | 0.4048** | 0.0924 | 0.3948** | 0.0909 | 0.3911** | 0.0910 |
| 2001 | 0.0215 | 0.0688 | 0.0228 | 0.0689 | 0.0360 | 0.0679 | 0.0370 | 0.0679 |
| 2002 | -0.0880 | 0.0702 | -0.0747 | 0.0701 | -0.0691 | 0.0694 | -0.0567 | 0.0692 |
| 2003 | -0.0401 | 0.0795 | -0.0241 | 0.0793 | -0.0173 | 0.0786 | -0.0024 | 0.0783 |
| 2004 | -0.0483 | 0.0709 | -0.0374 | 0.0708 | -0.0246 | 0.0702 | -0.0146 | 0.0701 |
| 2005 | 0.0157 | 0.0719 | 0.0355 | 0.0714 | 0.0408 | 0.0713 | 0.0592 | 0.0708 |
| 2006 | -0.1364* | 0.0667 | -0.1127 | 0.0659 | -0.1126 | 0.0661 | -0.0905 | 0.0653 |
| 2007 | 0.0402 | 0.0658 | 0.0572 | 0.0654 | 0.0597 | 0.0651 | 0.0755 | 0.0647 |
| 2008 | 0.0076 | 0.0679 | 0.0222 | 0.0677 | 0.0294 | 0.0673 | 0.0431 | 0.0670 |
| 2009 | 0.0289 | 0.0725 | 0.0483 | 0.0721 | 0.0439 | 0.0715 | 0.0621 | 0.0710 |
| 2010 | 0.0278 | 0.0749 | 0.0436 | 0.0747 | 0.0457 | 0.0739 | 0.0605 | 0.0737 |
| 2011 | 0.0103 | 0.0771 | 0.0279 | 0.0768 | 0.0317 | 0.0762 | 0.0481 | 0.0758 |
| 2012 | -0.0293 | 0.0864 | -0.0126 | 0.0862 | -0.0148 | 0.0851 | 0.0008 | 0.0849 |
| 2013 | -0.1485 | 0.0815 | -0.1400 | 0.0815 | -0.1405 | 0.0802 | -0.1326 | 0.0802 |
| 2014 | -0.2472** | 0.0748 | -0.2398** | 0.0748 | -0.2301** | 0.0738 | -0.2233** | 0.0738 |
| 2015 | -0.2097** | 0.0638 | -0.2023** | 0.0637 | -0.1939** | 0.0629 | -0.1872** | 0.0629 |
| 2016 | -0.1338* | 0.0626 | -0.1164 | 0.0622 | -0.1096 | 0.0622 | -0.0934 | 0.0617 |
| 2017 | -0.0142 | 0.0619 | 0.0047 | 0.0614 | 0.0101 | 0.0615 | 0.0278 | 0.0610 |

** significant at p 0.05, ** significant at p 0.01*

*Table 8: Results on split investment category € 10 - € 50 million*

| | **Model XXI: Hedonic regression €10 mln- €50 mln broker** | | **Model XXII: Hedonic regression €10 mln- €50 mln market share broker** | | **Model XXIII: STAR model €10 mln- €50 mln broker** | | **Model XXIV: STAR model €10 mln- €50 mln market share broker** | |
|---|---|---|---|---|---|---|---|---|
| Observations | 681 | | 681 | | 681 | | 681 | |
| R square | 0.5864 | | 0.5907 | | | | | |
| Adjusted R-square | 0.5693 | | 0.5737 | | | | | |
| Pseudo R square | | | | | 0.5876 | | 0.5922 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 13.4032** | 0.2419 | 13.3941** | 0.2406 | 12.5988** | 0.3734 | 12.5778** | 0.3712 |
| Broker | 0.0502 | 0.0311 | - | - | 0.0452 | 0.0302 | - | - |
| Market share broker | - | - | 0.0146** | 0.0047 | - | - | 0.0140** | 0.0046 |
| Spatiotemporal | - | - | - | - | 0.0960** | 0.0347 | 0.0975** | 0.0345 |
| LNAge | -0.0109 | 0.0165 | -0.0064 | 0.0165 | -0.0110 | 0.0160 | -0.0066 | 0.0160 |
| LNSurface | -0.6408** | 0.0227 | -0.6409** | 0.0226 | -0.6342** | 0.0222 | -0.6342 | 0.0220 |
| Government | -0.0352 | 0.1966 | -0.0648 | 0.1956 | -0.0145 | 0.1907 | -0.0420** | 0.1898 |
| Institution | 0.1913* | 0.0792 | 0.1865* | 0.0787 | 0.1868* | 0.0768 | 0.1818* | 0.0763 |
| Non-profit | 0.1038 | 0.1982 | 0.1088 | 0.1971 | 0.0655 | 0.1926 | 0.0703 | 0.1916 |
| Pooled fund | 0.2531** | 0.0756 | 0.2409** | 0.0754 | 0.2487** | 0.0733 | 0.2367* | 0.0731 |
| Private fund | 0.1196 | 0.0695 | 0.1118 | 0.0692 | 0.1167 | 0.0674 | 0.1088 | 0.0671 |
| Propco | 0.2371** | 0.0695 | 0.2356** | 0.0690 | 0.2356** | 0.0674 | 0.2337** | 0.0669 |
| REIT | 0.1303 | 0.0950 | 0.1258 | 0.0944 | 0.1238 | 0.0921 | 0.1188 | 0.0915 |
| 2001 | -0.1558 | 0.0824 | -0.1575 | 0.0820 | -0.1409 | 0.0801 | -0.1424 | 0.0797 |
| 2002 | -0.0513 | 0.0825 | -0.0486 | 0.0818 | -0.0332 | 0.0803 | -0.0311 | 0.0795 |
| 2003 | -0.0488 | 0.0881 | -0.0524 | 0.0870 | -0.0299 | 0.0857 | -0.0344 | 0.0846 |
| 2004 | -0.1044 | 0.0867 | -0.1060 | 0.0849 | -0.0934 | 0.0842 | -0.0966 | 0.0824 |
| 2005 | -0.0857 | 0.0814 | -0.0981 | 0.0802 | -0.0770 | 0.0790 | -0.0904 | 0.0778 |
| 2006 | 0.0391 | 0.0860 | 0.0314 | 0.0841 | 0.0431 | 0.0833 | 0.0338 | 0.0816 |
| 2007 | 0.2418* | 0.0931 | 0.2487 | 0.0914 | 0.2545** | 0.0904 | 0.2597** | 0.0887 |
| 2008 | 0.0848 | 0.0859 | 0.0770 | 0.0847 | 0.0944 | 0.0833 | 0.0856 | 0.0821 |
| 2009 | -0.0388 | 0.0982 | -0.0240 | 0.0953 | -0.0425 | 0.0952 | -0.0307 | 0.0924 |
| 2010 | -0.0236 | 0.0985 | -0.0163 | 0.0968 | -0.0220 | 0.0955 | -0.0166 | 0.0939 |
| 2011 | -0.0997 | 0.1021 | -0.0921 | 0.1004 | -0.0961 | 0.0990 | -0.0904 | 0.0973 |
| 2012 | -0.1903 | 0.1156 | -0.1755 | 0.1140 | -0.1886 | 0.1121 | -0.1759 | 0.1105 |
| 2013 | -0.1453 | 0.1226 | -0.1346 | 0.1205 | -0.1381 | 0.1188 | -0.1297 | 0.1168 |
| 2014 | -0.0203 | 0.0942 | -0.0334 | 0.0932 | -0.0127 | 0.0914 | -0.0267 | 0.0904 |
| 2015 | -0.0877 | 0.0877 | -0.1020 | 0.0866 | -0.0860 | 0.0851 | -0.1014 | 0.0840 |
| 2016 | -0.1141 | 0.0841 | -0.1179 | 0.0830 | -0.1171 | 0.0815 | -0.1222 | 0.0805 |
| 2017 | 0.0290 | 0.0781 | 0.0372 | 0.0762 | 0.0434 | 0.0758 | 0.0499 | 0.0740 |

** significant at p 0.05, ** significant at p 0.01*

*Table 9: Results on split investment category € 50 - € 100 million*

| | **Model XXV: Hedonic regression €50 mln- €100 mln broker** | | **Model XXVI: Hedonic regression €50 mln- €100 mln market share broker** | | **Model XXVII: STAR model €50 mln- €100 mln broker** | | **Model XXVIII: STAR model €50 mln- €100 mln market share broker** | |
|---|---|---|---|---|---|---|---|---|
| Observations | 136 | | 136 | | 136 | | 136 | |
| R square | 0.9225 | | 0.9227 | | | | | |
| Adjusted R-square | 0.9040 | | 0.9042 | | | | | |
| Pseudo R square | | | | | 0.9231 | | 0.9234 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 16.5756** | 0.3118 | 16.5873** | 0.3101 | 16.7135** | 0.3141 | 12.6175** | 0.3637 |
| Broker | -0.0131 | 0.0370 | - | - | -0.0149 | 0.0331 | - | - |
| Market share broker | - | - | -0.0030 | 0.0050 | - | - | 0.0142** | 0.0046 |
| Spatiotemporal | - | - | | | -0.0172 | 0.0182 | 0.0974** | 0.0344 |
| LNAge | -0.0017 | 0.0163 | -0.0029 | 0.0164 | -0.0021 | 0.0145 | -0.0063 | 0.0160 |
| LNSurface | -0.8214** | 0.0306 | -0.8220** | 0.0306 | -0.8235** | 0.0274 | -0.6347** | 0.0220 |
| Government | -0.4788 | 0.2856 | -0.4835 | 0.2854 | -0.4689 | 0.2550 | -0.0399 | 0.1898 |
| Institution | -0.4513** | 0.2230 | -0.4528* | 0.2215 | -0.4401* | 0.1993 | 0.1758* | 0.0758 |
| Non-profit | -0.7625* | 0.2944 | -0.7610* | 0.2940 | -0.7389** | 0.2638 | 0.0686 | 0.1916 |
| Pooled fund | -0.2859 | 0.2206 | -0.2879 | 0.2187 | -0.2708 | 0.1974 | 0.2369** | 0.0731 |
| Private fund | -0.3328 | 0.2231 | -0.3316 | 0.2220 | -0.3269 | 0.1991 | 0.1081 | 0.0671 |
| Propco | -0.3099 | 0.2182 | -0.3154 | 0.2162 | -0.2992 | 0.1949 | 0.2301** | 0.0667 |
| REIT | -0.3453 | 0.2252 | -0.3407 | 0.2248 | -0.3318 | 0.2013 | 0.1172 | 0.0915 |
| 2001 | -0.1089 | 0.1390 | -0.1074 | 0.1389 | -0.1028 | 0.1242 | -0.1753** | 0.0628 |
| 2002 | -0.0317 | 0.1448 | -0.0337 | 0.1411 | -0.0184 | 0.1299 | -0.0645 | 0.0621 |
| 2003 | -0.0868 | 0.1038 | -0.0889 | 0.1003 | -0.0729 | 0.0938 | -0.0673 | 0.0690 |
| 2004 | -0.0562 | 0.0886 | -0.0585 | 0.0871 | -0.0455 | 0.0798 | -0.1295 | 0.0664 |
| 2005 | -0.0744 | 0.1044 | -0.0769 | 0.1009 | -0.0628 | 0.0939 | -0.1240* | 0.0598 |
| 2006 | 0.0993 | 0.0782 | 0.1027 | 0.0767 | 0.1139 | 0.0715 | -0.0000 | 0.0644 |
| 2007 | 0.0355 | 0.0836 | 0.0357 | 0.0830 | 0.0473 | 0.0756 | 0.2255** | 0.0727 |
| 2008 | 0.0375 | 0.0842 | 0.0382 | 0.0828 | 0.0534 | 0.0770 | 0.0516 | 0.0649 |
| 2009 | 0.1532 | 0.1209 | 0.1568 | 0.1200 | 0.1655 | 0.1086 | -0.0648 | 0.0775 |
| 2010 | 0.1143 | 0.0939 | 0.1152 | 0.0925 | 0.1312 | 0.0856 | -0.0504 | 0.0795 |
| 2011 | -0.1227 | 0.0927 | -0.1221 | 0.0893 | -0.1072 | 0.0843 | -0.1240 | 0.0837 |
| 2012 | 0.0832 | 0.1057 | 0.0768 | 0.1002 | 0.0993 | 0.0958 | -0.2102 | 0.0983 |
| 2013 | - | - | - | - | - | - | - | - |
| 2014 | -0.0462 | 0.0856 | -0.0495 | 0.0831 | -0.0366 | 0.0770 | -0.1644 | 0.1049 |
| 2015 | -0.0299 | 0.0909 | -0.0194 | 0.0922 | -0.0179 | 0.0820 | -0.0616 | 0.0742 |
| 2016 | -0.0459 | 0.0821 | -0.0461 | 0.0797 | -0.0317 | 0.0748 | -0.1360* | 0.0666 |
| 2017 | 0.0101 | 0.0788 | 0.0090 | 0.0752 | 0.0238 | 0.0718 | -0.1558* | 0.0633 |

** significant at p 0.05, ** significant at p 0.01*

*Table 10: Results on split investment category > € 100 million*

| | **Model XXIX: Hedonic regression >€100 mln broker** | | **Model XXX: Hedonic regression >€100 mln market share broker** | | **Model XXXI: STAR model > €100 mln broker** | | **Model XXXII: STAR model > €100 mln market share broker** | |
|---|---|---|---|---|---|---|---|---|
| Observations | 50 | | 50 | | 50 | | 50 | |
| R square | 0.5623 | | 0.6003 | | | | | |
| Adjusted R-square | 0.2341 | | 0.3005 | | | | | |
| Pseudo R square | | | | | 0.6385 | | 0.6462 | |
| | Coeff. | S.E. | Coeff. | S.E. | Coeff. | S.E | Coeff. | S.E |
| Constant | 15.4767** | 1.9343 | 16.1657** | 1.8962 | 13.7098** | 1.4001 | 14.3285** | 1.4627 |
| Broker | 0.1552 | 0.1590 | - | - | 0.0695 | 0.1099 | - | - |
| Market share broker | - | - | 0.0440 | 0.0229 | - | - | 0.0244 | 0.0173 |
| Spatiotemporal | - | - | - | - | 0.6732** | 0.196031 | 0.5869** | 0.2047 |
| LNAge | 0.0011 | 0.0602 | 0.0080 | 0.0577 | -0.0149 | 0.0408 | -0.0089 | 0.0404 |
| LNSurface | -0.6682** | 0.1645 | -0.7412** | 0.1634 | -0.5278 | 0.1181 | -0.5871** | 0.1254 |
| Government | - | - | - | - | - | - | - | - |
| Institution | -0.0998 | 0.3114 | -0.0074 | 0.2994 | 0.1692 | 0.2237 | 0.1853 | 0.2183 |
| Non-profit | -0.2416 | 0.3272 | -0.1636 | 0.3103 | -0.0701 | 0.2259 | -0.0503 | 0.2188 |
| Pooled fund | - | - | - | - | - | - | - | - |
| Private fund | -0.0101 | 0.3107 | 0.0955 | 0.3020 | 0.0594 | 0.2101 | 0.1091 | 0.2095 |
| Propco | -0.1909 | 0.3198 | -0.1162 | 0.2962 | 0.0005 | 0.2224 | 0.0147 | 0.2104 |
| REIT | -0.2183 | 0.5298 | -0.1924 | 0.4975 | -5.4334** | 1.5599 | -4.7544** | 1.6278 |
| 2001 | - | - | - | - | - | - | - | - |
| 2002 | - | - | - | - | - | - | - | - |
| 2003 | -0.2657 | 0.4167 | -0.2841 | 0.3982 | -5.6264** | 1.5860 | -4.9493** | 1.6501 |
| 2004 | -0.3034 | 0.4275 | -0.3216 | 0.4072 | -5.5754** | 1.5619 | -4.9116** | 1.6253 |
| 2005 | -0.3629 | 0.4720 | -0.3880 | 0.4453 | -5.4731** | 1.5216 | -4.8356** | 1.5814 |
| 2006 | -0.0050 | 0.4093 | 0.0126 | 0.3849 | -5.1791** | 1.5317 | -4.5090** | 1.5992 |
| 2007 | -0.2434 | 0.4212 | -0.2853 | 0.4023 | -5.4617** | 1.5458 | -4.8180** | 1.6051 |
| 2008 | -0.3023 | 0.4908 | -0.3322 | 0.4694 | -5.5822** | 1.5726 | -4.9224** | 1.6334 |
| 2009 | - | - | - | - | - | - | - | - |
| 2010 | -0.2956 | 0.4514 | -0.3586 | 0.4204 | -5.5811** | 1.5688 | -4.9441** | 1.6254 |
| 2011 | -0.1334 | 0.4791 | -0.0165 | 0.4443 | -5.5906** | 1.6215 | -4.8304** | 1.7067 |
| 2012 | - | - | - | - | - | - | - | - |
| 2013 | 0.3174 | 0.5359 | 0.4373 | 0.5003 | -5.0476** | 1.6034 | -4.2975* | 1.6872 |
| 2014 | -0.0036 | 0.4342 | -0.0220 | 0.4145 | -5.5097** | 1.6298 | -4.8136** | 1.6954 |
| 2015 | -0.1167 | 0.4593 | -0.0040 | 0.4210 | -5.3257** | 1.5480 | -4.6001** | 1.6291 |
| 2016 | 0.0288 | 0.4323 | -0.0877 | 0.4184 | -5.371** | 1.5993 | -4.7471** | 1.6505 |
| 2017 | 0.0300 | 0.4188 | -0.0012 | 0.3905 | -5.3308** | 1.5863 | -4.6655** | 1.6489 |

** significant at p 0.05, ** significant at p 0.01*

# 5 CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

This research studies the impact of the use of a broker and the market share of a broker on the transaction price per square meter during an office investment in the Netherlands for the period 2000-2017. An investor can choose to use a broker or not. Motives to use a broker are on the one hand that the broker can advise the investor during the purchase process. On the other hand, the purchaser may expect the broker to ease the information asymmetry between him and the seller (McAllister & Nanda, 2016). This asymmetry is the result of the seller having superior information on the current market conditions and better knowledge of the building characteristics (Milgrom & Stockey, 1982).

According to previous research on the effect of the use of a broker, using a broker actually increases the transaction prices. To create an understanding of the effect of the use of a broker two elements have been researched. First, the effect of using a broker or no broker and second, the effect of the market share of the used broker. For the determination of these effects several baseline hedonic regressions and STAR models have been performed. The analyses have been conducted on the Netherlands and on a subsample of Amsterdam. Next to that, a sensitivity analysis is added to create understanding of the uncertainty of the model. (Saltelli, 2002).

Results of the analysis for the use of a broker show that when using a broker, purchasers are faced with a 3.6% price premium on their transaction price per square meter. These price premiums are similar in Amsterdam, amounting to 3.7%. These price premiums slightly decreased to 3.2% after the global financial crisis. Within the different investment volume categories differences between the price premiums of transactions prices came forward. Investment volumes smaller than € 10 million are faced with a price premium of 6.2%, investment values between € 10 million and € 50 million are faced with price premiums of 4.5%, and price premiums for the investment category larger than € 100 million amount to 7.0%. However, only the smallest investment category (< € 10 million) shows significant results on a 1% significance level. Finally, in the investment category € 50 million - € 100 million a decrease of prices of 1.5% is to be seen, when purchaser use a broker, this result, however, not being significant.

The results of the analysis on the market share of a broker show that there is a relation between the market share of a broker and the transaction prices per square meter. For the Netherlands percentage increase in the market share of a broker results in a 0.5% increase in the transaction price per square meter (on a 5% significance level). These results are slightly higher for the subsample of Amsterdam and amount to 0.9% (not significant). In addition, for the various investment categories different price premiums are found. Whereas the largest price premiums of 2.4% are seen in the investment category larger than € 100 million, the smallest price premiums in the smallest investment category (< € 10 million) amount to 0.7%.

These results combined answer the research question: “How does the use of a broker during an office transaction influence the transaction price?”. Both the null hypotheses of the research stating that there is no relation between the use of a broker and the transaction price per square meter, and that there is no relation between the market share of a broker and the transaction prices per square meter, can be rejected. The results of this research indicate that in general using a broker increases transaction prices per square meter and when using a broker with a higher market share transaction prices will increase even further. An interesting result is that for the investment category € 50 million - € 100 million, prices decease slightly, when purchasers use a broker.

### 5.2 Limitations and recommendations future research

This research was confronted with some limitations, all related to the quality of the data. First, the rental market and thus the yields of the investments: are opaque. The yields and rental rates in an office building, however, largely influence the transaction price of the office buildings and the risk associated with the investment. Next to that, more information on the buildings, which would have resulted in a better research, was not available. The last limitation was that the quality of the data out of the early years addressed by this research is poorer than the quality of the data out of the recent years, both with regard to the amount of available data and their completeness. Lastly, there are other variables that have not been researched and that could lead to different outcomes, such as the levels of vacancy in the building, the duration of rental contracts, the financial stability of an occupier, vacancy rates in the vicinity and finally the difference between the contract rent and the market rent. The inclusion of these variables and the existence of more complete datasets could both result in different outcomes.

Multiple opportunities for future research can be derived from these results. Future research could focus on different markets or on different countries. As well, research could looking into the use of a broker in different sectors. Other research possibilities could be to include more variables on rental contracts and yields. Finally, it could be interesting to perform the same research for another country, as the Dutch real estate market is considered a transparent market according to JLL (2016), therefore comparing this to a more opaque market could lead to different outcomes.

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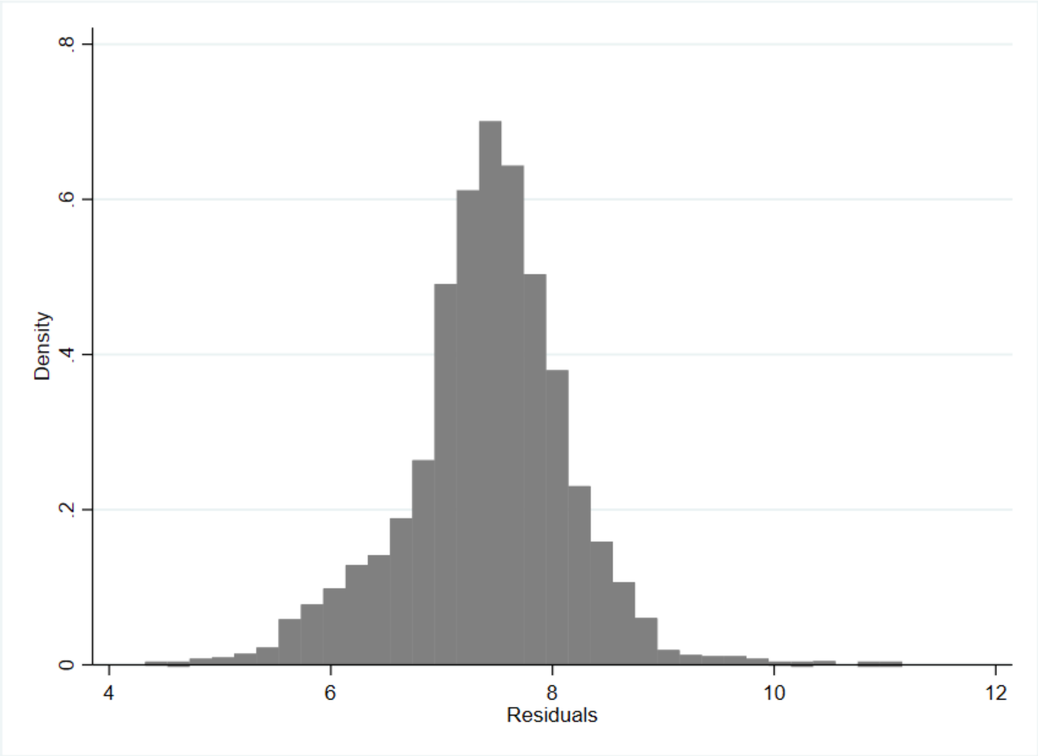
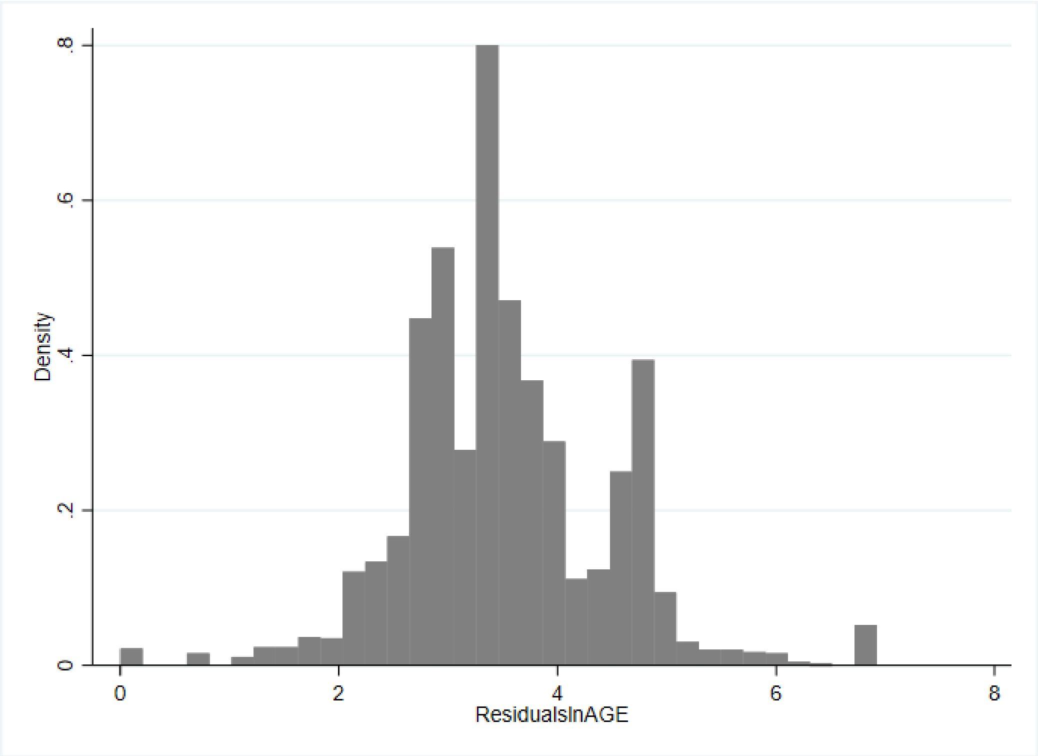
## APPENDIX

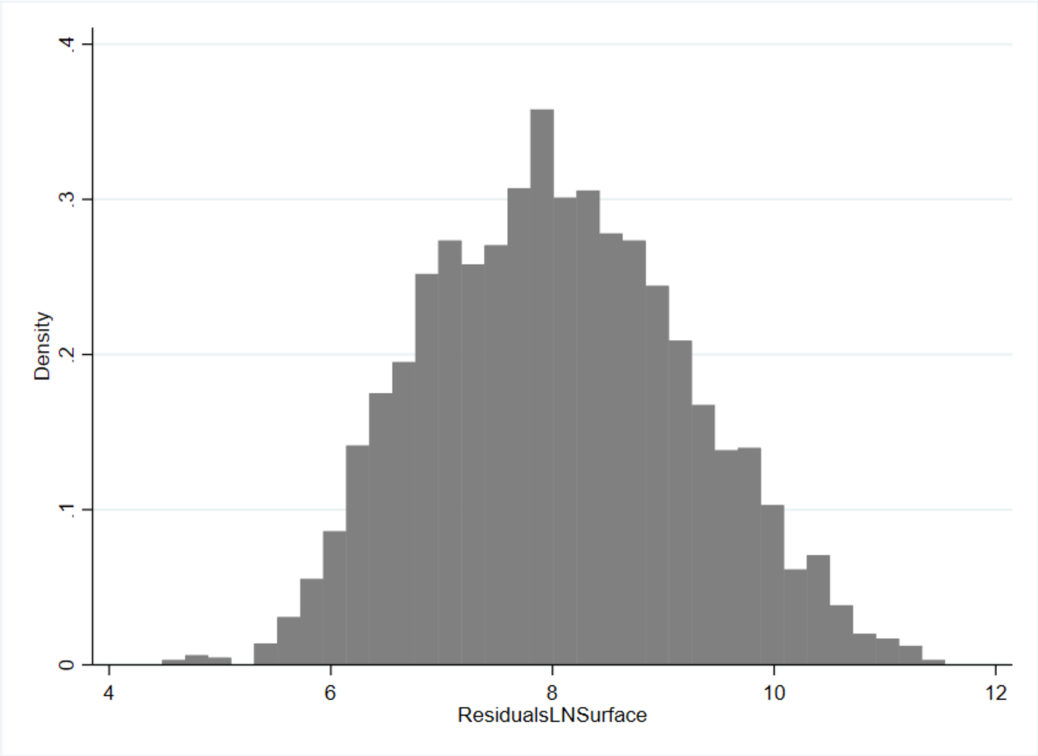
*Appendix 1: Histogram residual logarithm transaction price per square meter*




*Appendix 2: Histogram residual logarithm age building*

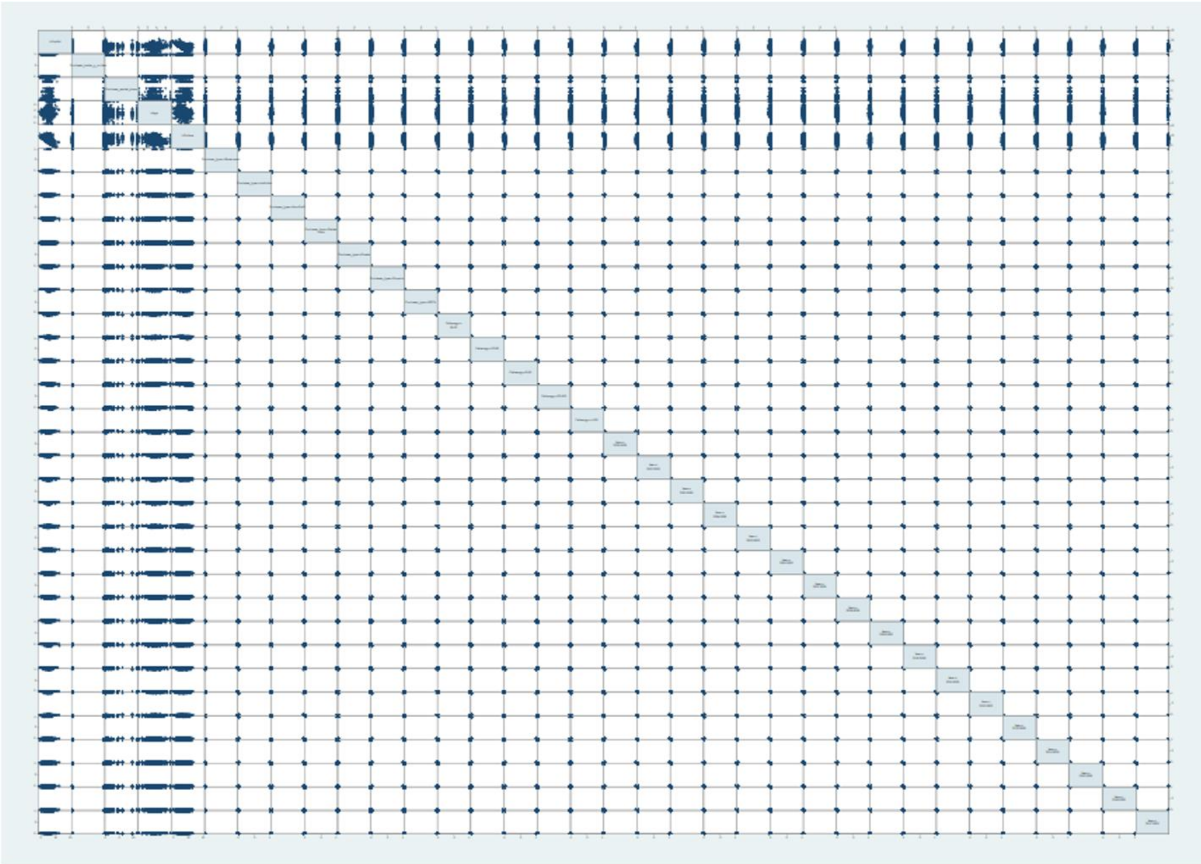


*Appendix 3: Histogram residuals logarithm surface*



Before performing a hedonic regression the OLS assumptions need to be tested.

1. Linear relationship: there should be a linear relation between the dependent and each of the independent variables.



2. Homoscedasticity of residuals: the graph shows a slightly heteroscedastic result. The results of the Breusch-Pagan / Cook-Weisberg test confirm this. This can be solved by using Whit's robust standard errors (which are larger than normal standard errors)

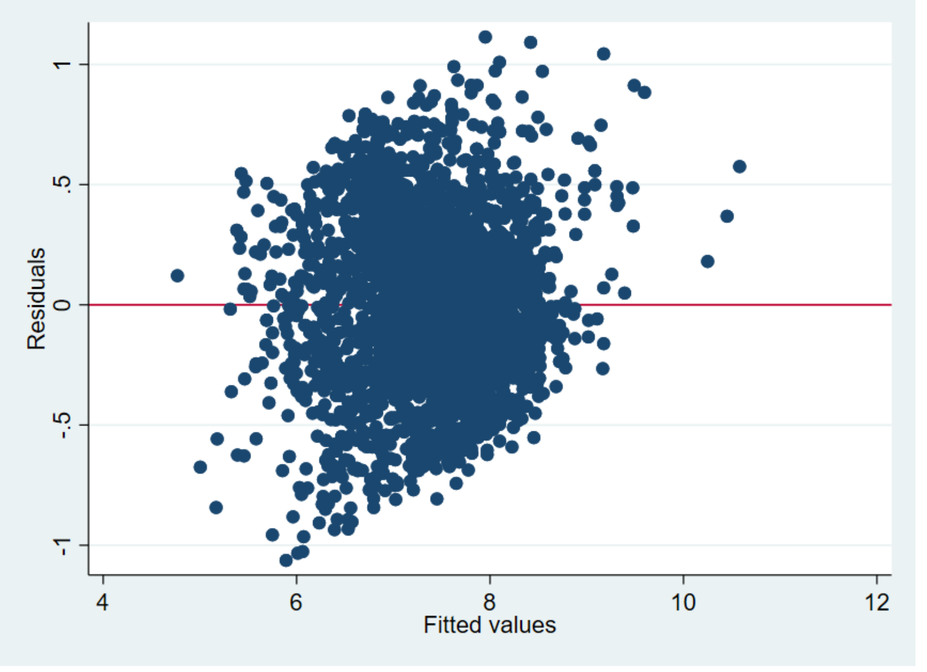
*Breusch-Pagan / Cook-Weisberg test for heteroskedasticity*

H0: constant variance

Variables: fitted values of lnCapitalValue

Chi2(1) = 61.18

Prob > chi2 = 0.000

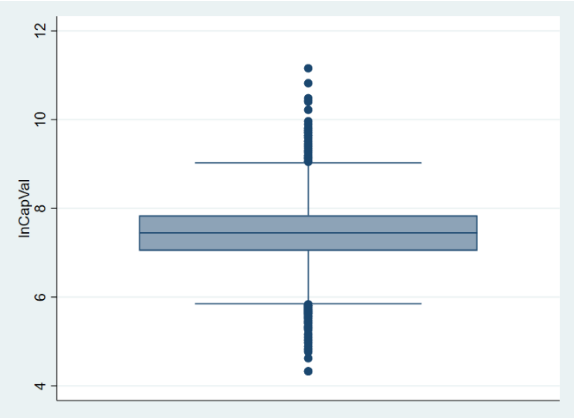


3. Multicollinearity: the data cannot contain multicollinearity. The correlation matrix below shows that there are no issues with multicollinearity.

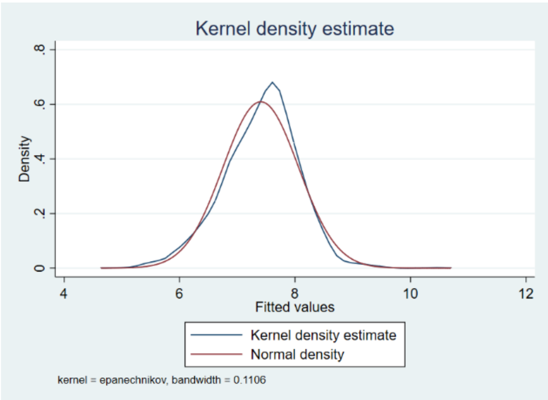
| | Broker | Market shar | Spatiotempo | LNAge | LNSurface | Government | Institution | Non-profit | Pooled fund | Private fund | Propco | REIT | € 5 - € 10 mi | € 10 - € 25 m | € 25 - € 50 m | € 50 - € 100 | > € 100 milli | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Broker | 1.0000 |
| Market shar | 0.0980 | 1.0000 |
| Spatiotempo | 0.0828 | 0.5503 | 1.0000 |
| LNAge | 0.0422 | -0.1008 | -0.1048 | 1.0000 |
| LNSurface | -0.2414 | 0.1177 | 0.1507 | -0.3026 | 1.0000 |
| Government | 0.0018 | 0.0145 | 0.0217 | 0.0095 | 0.0350 | 1.0000 |
| Institution | 0.0773 | -0.0260 | 0.0178 | -0.0368 | 0.1295 | -0.0175 | 1.0000 |
| Non-profit | -0.0498 | 0.0093 | -0.0187 | 0.0486 | -0.0145 | -0.0104 | -0.0313 | 1.0000 |
| Pooled fund | 0.0899 | 0.0786 | 0.1203 | -0.1054 | 0.2054 | -0.0223 | -0.0673 | -0.0399 | 1.0000 |
| Private fund | -0.1589 | -0.0867 | -0.1046 | 0.2066 | -0.4072 | -0.0938 | -0.2835 | -0.1680 | -0.3611 | 1.0000 |
| Propco | 0.1362 | 0.0869 | 0.0390 | -0.1953 | 0.2600 | -0.0345 | -0.1043 | -0.0618 | -0.1329 | -0.5602 | 1.0000 |
| REIT | 0.0487 | -0.0238 | 0.0089 | -0.0481 | 0.0670 | -0.0122 | -0.0367 | -0.0218 | -0.0468 | -0.1972 | -0.0726 | 1.0000 |
| € 5 - € 10 mi | 0.1152 | 0.0409 | 0.0565 | -0.1240 | 0.3053 | 0.0053 | 0.0780 | -0.0418 | 0.0909 | -0.2189 | 0.1645 | 0.0521 | 1.0000 |
| € 10 - € 25 m | 0.1699 | 0.0912 | 0.1072 | -0.0929 | 0.3458 | -0.0056 | 0.0845 | -0.0207 | 0.0920 | -0.2276 | 0.1734 | 0.0245 | -0.1161 | 1.0000 |
| € 25 - € 50 m | -0.0025 | -0.0269 | -0.0271 | -0.0314 | 0.1098 | 0.0010 | 0.0462 | 0.0116 | 0.0002 | -0.0628 | 0.0242 | 0.0634 | -0.1790 | -0.1251 | 1.0000 |
| € 50 - € 100 | 0.1885 | 0.1080 | 0.1286 | -0.1232 | 0.3466 | 0.0045 | 0.0372 | -0.0173 | 0.1643 | -0.1893 | 0.1197 | 0.0363 | -0.0869 | -0.0607 | -0.0936 | 1.0000 |
| > € 100 milli | 0.1362 | 0.0711 | 0.0520 | -0.0840 | 0.2781 | 0.0577 | 0.0641 | -0.0174 | 0.0761 | -0.1259 | 0.0911 | -0.0204 | -0.0519 | -0.0363 | -0.0560 | -0.0272 | 1.0000 |
| 2001 | -0.0152 | -0.1724 | -0.0920 | 0.0087 | 0.0044 | -0.0183 | 0.0602 | -0.0328 | -0.0290 | 0.0235 | -0.0313 | 0.0604 | 0.0541 | -0.0261 | 0.0160 | -0.0376 | -0.0307 | 1.0000 |
| 2002 | -0.0024 | -0.0426 | -0.0410 | -0.0008 | 0.0054 | 0.0006 | 0.0232 | -0.0218 | 0.0880 | -0.0591 | 0.0312 | 0.0074 | 0.0367 | 0.0182 | -0.0006 | -0.0369 | -0.0190 | -0.0574 | 1.0000 |
| 2003 | 0.0025 | 0.0013 | -0.0111 | -0.0172 | 0.0474 | 0.0076 | 0.0018 | -0.0012 | -0.0509 | -0.0292 | 0.0692 | 0.0233 | 0.0176 | 0.0539 | -0.0120 | - | 0.0158 | -0.0471 | -0.0465 | 1.0000 |
| 2004 | 0.0169 | 0.0208 | 0.0414 | 0.0380 | 0.0115 | 0.0007 | 0.0301 | -0.0004 | 0.0149 | -0.0343 | 0.0433 | -0.0288 | 0.0130 | 0.0079 | -0.0077 | 0.0052 | 0.0264 | -0.0572 | -0.0565 | -0.0464 | 1.0000 |
| 2005 | 0.0337 | 0.0581 | 0.0531 | 0.0078 | 0.0412 | 0.0186 | 0.1430 | -0.0016 | -0.0086 | -0.1184 | 0.0759 | -0.0387 | 0.0574 | 0.0266 | 0.0533 | -0.0104 | -0.0085 | -0.0583 | -0.0576 | -0.0472 | -0.0574 | 1.0000 |
| 2006 | 0.0404 | 0.1257 | 0.0926 | -0.0158 | -0.0258 | -0.0050 | -0.0078 | -0.0104 | -0.0225 | -0.0075 | 0.0497 | 0.0027 | -0.0259 | 0.0138 | -0.0291 | 0.0310 | 0.0233 | -0.0674 | -0.0666 | -0.0546 | -0.0664 | -0.0676 | 1.0000 |
| 2007 | 0.0786 | 0.0150 | -0.0094 | 0.0167 | -0.0545 | -0.0040 | -0.0395 | -0.0277 | -0.0283 | 0.0300 | -0.0064 | 0.0373 | -0.0569 | -0.0010 | 0.0174 | 0.0038 | 0.0457 | -0.0657 | -0.0648 | -0.0532 | -0.0646 | -0.0659 | -0.0761 | 1.0000 |
| 2008 | 0.0712 | -0.0014 | 0.0001 | 0.0177 | -0.0638 | -0.0194 | -0.0035 | 0.0252 | -0.0301 | 0.0320 | -0.0307 | 0.0106 | -0.0046 | 0.0135 | -0.0032 | 0.0046 | -0.0325 | -0.0615 | -0.0607 | -0.0498 | -0.0605 | -0.0617 | -0.0713 | -0.0694 | 1.0000 |
| 2009 | 0.0352 | 0.0536 | 0.0077 | 0.0269 | -0.0481 | 0.0462 | -0.0128 | 0.0181 | -0.0330 | 0.0274 | -0.0254 | -0.0037 | 0.0034 | -0.0187 | -0.0035 | -0.0221 | -0.0145 | -0.0512 | -0.0506 | -0.0415 | -0.0504 | -0.0514 | -0.0594 | -0.0578 | -0.0541 | 1.0000 |
| 2010 | 0.0463 | 0.0097 | -0.0166 | -0.0065 | -0.0281 | 0.0492 | -0.0170 | -0.0034 | -0.0355 | 0.0452 | -0.0059 | -0.0221 | -0.0085 | -0.0024 | -0.0231 | 0.0126 | 0.0131 | -0.0492 | -0.0486 | -0.0398 | -0.0484 | -0.0493 | -0.0570 | -0.0555 | -0.0520 | -0.0433 | 1.0000 |
| 2011 | 0.0197 | 0.0281 | -0.0037 | -0.0004 | -0.0216 | -0.0146 | -0.0361 | -0.0003 | -0.0241 | 0.0495 | 0.0001 | -0.0085 | -0.0040 | -0.0087 | -0.0091 | 0.0269 | -0.0244 | -0.0462 | -0.0457 | -0.0374 | -0.0455 | -0.0464 | -0.0536 | -0.0522 | -0.0489 | -0.0407 | -0.0391 | 1.0000 |
| 2012 | 0.0135 | 0.0086 | -0.0240 | 0.0335 | -0.0362 | -0.0116 | -0.0252 | 0.0274 | -0.0048 | 0.0314 | -0.0179 | -0.0106 | 0.0054 | -0.0108 | -0.0203 | -0.0325 | 0.0148 | -0.0367 | -0.0363 | -0.0298 | -0.0362 | -0.0368 | -0.0426 | -0.0415 | -0.0388 | -0.0323 | -0.0311 | -0.0292 | 1.0000 |
| 2013 | -0.0414 | -0.0097 | -0.0123 | -0.0078 | 0.0164 | -0.0126 | -0.0288 | -0.0225 | 0.0033 | -0.0085 | 0.0413 | -0.0264 | -0.0104 | -0.0244 | 0.0031 | 0.0136 | -0.0052 | -0.0398 | -0.0393 | -0.0322 | -0.0392 | -0.0399 | -0.0462 | -0.0449 | -0.0421 | -0.0350 | -0.0337 | -0.0316 | -0.0251 | 1.0000 |
| 2014 | -0.0630 | -0.0364 | 0.0074 | -0.0204 | 0.0483 | 0.0468 | 0.0024 | 0.0187 | 0.0558 | -0.0138 | -0.0620 | -0.0134 | 0.0002 | 0.0121 | -0.0280 | 0.0328 | -0.0016 | -0.0508 | -0.0502 | -0.0411 | -0.0500 | -0.0510 | -0.0589 | -0.0574 | -0.0537 | -0.0447 | -0.0430 | -0.0404 | -0.0321 | -0.0348 | 1.0000 |
| 2015 | -0.1034 | -0.0545 | 0.0047 | 0.0086 | 0.0053 | -0.0222 | -0.0345 | 0.0224 | 0.0378 | 0.0159 | -0.0285 | -0.0315 | -0.0307 | -0.0156 | -0.0315 | -0.0098 | -0.0088 | -0.0704 | -0.0696 | -0.0570 | -0.0693 | -0.0706 | -0.0817 | -0.0795 | -0.0745 | -0.0620 | -0.0596 | -0.0560 | -0.0445 | -0.0482 | -0.0615 | 1.0000 |
| 2016 | -0.0733 | 0.0581 | 0.0623 | -0.0295 | -0.0096 | -0.0248 | -0.0601 | -0.0120 | 0.0331 | 0.0118 | -0.0157 | -0.0313 | -0.0338 | -0.0354 | -0.0196 | -0.0110 | -0.0070 | -0.0787 | -0.0777 | -0.0637 | -0.0774 | -0.0789 | -0.0912 | -0.0888 | -0.0832 | -0.0693 | -0.0665 | -0.0625 | -0.0497 | -0.0538 | -0.0687 | -0.0953 | 1.0000 |
| 2017 | -0.0249 | 0.0475 | -0.0179 | -0.0154 | 0.0471 | -0.0139 | -0.0453 | 0.0266 | 0.0373 | 0.0551 | -0.1008 | 0.0075 | 0.0012 | -0.0063 | 0.0537 | 0.0028 | 0.0187 | -0.0862 | -0.0852 | -0.0699 | -0.0849 | -0.0865 | -0.1000 | -0.0974 | -0.0912 | -0.0759 | -0.0729 | -0.0686 | -0.0545 | -0.0590 | -0.0753 | -0.1045 | -0.1167 | 1.0000 |

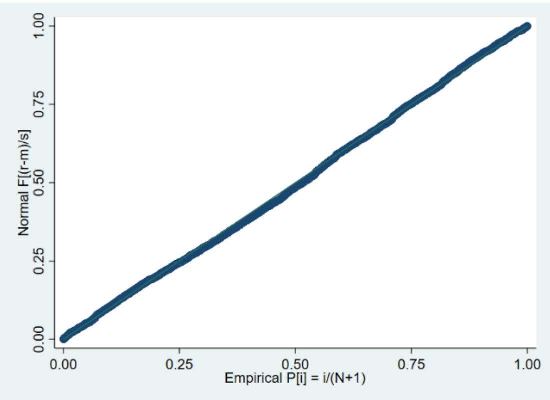
4. The covariance between errors is zero. To overcome this problem time effects have been included.

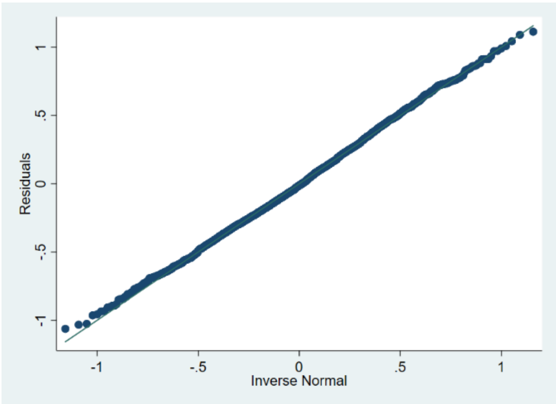
5. No significant outliers: to check this a boxplot has been created of the dependent variable, and outliers have been removed.




6. Normal distribution of the errors:




Shapiro-Wilk W test for normal data:

| *Variable* | *Obs* | *W* | *V* | *Z* | *Prob>z* |
|---|---|---|---|---|---|
| *R* | 3.130 | 0.99867 | 2.368 | 2.227 | 0.01297 |

*Appendix 5: Do file*

**Netherlands**

```
clear
import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_NL.xlsx", sheet("Sheet1") firstrow
destring _all, replace
gen lnCapVal = ln(Capital_value)
tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)
tab Purchaser_broker_y_n , gen(BrokerYN)
gen lnAge = ln(Age)
gen lnSurface = ln(Surface)
tab Year, gen(YR)
tab Purchaser_type , gen(Purshasertypes)
tab Catherogy, gen(cat)
gen residuals = lnCapVal
hist residuals
rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
summarize_all
Correlate lnCapVal BrokerYN2 Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
cd C:\Users\sterr\Documents
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
predict r, resid
rvfplot, yline(0)
estat imtest
estat hettest
graph matrix lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
pnorm r
qnorm r
swilk r
kdensity r,normal
graph box lnCapVal
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
```

```
assert Nummer
bysort Nummer: assert _N==1
spset Nummer,coord( Lat Long)
spset, modify coordsys(latlong,kilometers)
set matsize 11000
spmatrix create idistance Matrix_NL
spmatrix export Matrix_NL using Matrix_NL

[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix
Option Explicit
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
Second sheet called rank
=RANK(original!B2,original!$B2:$DPN2)
Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]

spmatrix import Matrix_NLgoede using Matrix_NLgoede, replace
spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_NLgoede) force

spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_NLgoede) force
```

**Amsterdam**

```
clear
import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_AMS.xlsx", sheet("Sheet1") firstrow
destring _all, replace
gen lnCapVal = ln(Capital_value)
tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)
tab Purchaser_broker_y_n , gen(BrokerYN)
gen lnAge = ln(Age)
gen lnSurface = ln(Surface)
tab Year, gen(YR)
tab Purchaser_type , gen(Purshasertypes)
tab Catherogy, gen(cat)
rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
```

```
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
cd C:\Users\sterr\Documents
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
assert Nummer
bysort Nummer: assert _N==1
spset Nummer,coord( Lat Long)
spset, modify coordsys(latlong,kilometers)
set matsize 11000
spmatrix create idistance Matrix_NL
spmatrix export Matrix_NL using Matrix_NL

[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix
Option Explicit
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
Second sheet called rank
=RANK(original!B2,original!$B2:$DPN2)
Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]

spmatrix import Matrix_AMSgoede using Matrix_AMSgoede, replace
spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_AMSgoede) force
spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_AMSgoede) force
```

**2000-2008**

```
clear
```

```
import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_2008.xlsx", sheet("Sheet1") firstrow
destring _all, replace
gen lnCapVal = ln(Capital_value)
tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)
tab Purchaser_broker_y_n , gen(BrokerYN)
gen lnAge = ln(Age)
gen lnSurface = ln(Surface)
tab Year, gen(YR)
tab Purchaser_type , gen(Purshasertypes)
tab Catherogy, gen(cat)
rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
cd C:\Users\sterr\Documents
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
assert Nummer
bysort Nummer: assert _N==1
spset Nummer,coord( Lat Long)
spset, modify coordsys(latlong,kilometers)
set matsize 11000
spmatrix create idistance Matrix_2008
spmatrix export Matrix_2008 using Matrix_2008
```

[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix

```
Option Explicit
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
```

Second sheet called rank

```
=RANK(original!B2,original!$B2:$DPN2)
```

Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]

```
spmatrix import Matrix_2008goede using Matrix_2008goede, replace
spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_2008goede) force
spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_2008goede) force
```

**2009-2017**

```
clear
import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_2017.xlsx", sheet("Sheet1") firstrow
destring _all, replace
gen lnCapVal = ln(Capital_value)
tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)
tab Purchaser_broker_y_n , gen(BrokerYN)
gen lnAge = ln(Age)
gen lnSurface = ln(Surface)
tab Year, gen(YR)
tab Purchaser_type , gen(Purshasertypes)
tab Catherogy, gen(cat)
rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
cd C:\Users\sterr\Documents
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
assert Nummer
bysort Nummer: assert _N==1
spset Nummer,coord( Lat Long)
```

```
spset, modify coordsys(latlong,kilometers)
set matsize 11000
spmatrix create idistance Matrix_2017
spmatrix export Matrix_2017 using Matrix_2017

[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix
Option Explicit
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
Second sheet called rank
=RANK(original!B2,original!$B2:$DPN2)
Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]

spmatrix import Matrix_2017goede using Matrix_2017goede, replace
spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_2017goede) force
spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_2017goede) force
```

**< € 10 mln**

```
clear
import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_10.xlsx", sheet("Sheet1") firstrow
destring _all, replace
gen lnCapVal = ln(Capital_value)
tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)
tab Purchaser_broker_y_n , gen(BrokerYN)
gen lnAge = ln(Age)
gen lnSurface = ln(Surface)
tab Year, gen(YR)
tab Purchaser_type , gen(Purshasertypes)
tab Catherogy, gen(cat)
rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
```

```
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
cd C:\Users\sterr\Documents
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
assert Nummer
bysort Nummer: assert _N==1
spset Nummer,coord( Lat Long)
spset, modify coordsys(latlong,kilometers)
set matsize 11000
spmatrix create idistance Matrix_10
spmatrix export Matrix_10 using Matrix_10


[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix
Option Explicit
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
Second sheet called rank
=RANK(original!B2,original!$B2:$DPN2)
Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]

spmatrix import Matrix_10goede using Matrix_10goede, replace
spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_10goede) force
spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_10goede) force
```

**€ 10 mln - € 50 mln**

```
clear
import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_50.xlsx", sheet("Sheet1") firstrow
destring _all, replace
gen lnCapVal = ln(Capital_value)
tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)
tab Purchaser_broker_y_n , gen(BrokerYN)
```

```
gen lnAge = ln(Age)
gen lnSurface = ln(Surface)
tab Year, gen(YR)
tab Purchaser_type , gen(Purshasertypes)
tab Catherogy, gen(cat)
rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
cd C:\Users\sterr\Documents
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
assert Nummer
bysort Nummer: assert _N==1
spset Nummer,coord( Lat Long)
spset, modify coordsys(latlong,kilometers)
set matsize 11000
spmatrix create idistance Matrix_50
spmatrix export Matrix_50 using Matrix_50

[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix
Option Explicit
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
Second sheet called rank
=RANK(original!B2,original!$B2:$DPN2)
Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]

spmatrix import Matrix_50goede using Matrix_50goede, replace
```

spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_50goede) force

spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_50goede) force

**€ 50 mln - € 100 mln**

clear

import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_100.xlsx", sheet("Sheet1") firstrow

destring _all, replace

gen lnCapVal = ln(Capital_value)

tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)

tab Purchaser_broker_y_n , gen(BrokerYN)

gen lnAge = ln(Age)

gen lnSurface = ln(Surface)

tab Year, gen(YR)

tab Purchaser_type , gen(Purshasertypes)

tab Catherogy, gen(cat)

rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
cd C:\Users\sterr\Documents

reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR17

reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR17

assert Nummer

bysort Nummer: assert _N==1

spset Nummer,coord( Lat Long)

spset, modify coordsys(latlong,kilometers)

set matsize 11000

spmatrix create idistance Matrix_100

spmatrix export Matrix_100 using Matrix_100

[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix
Option Explicit

```
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
```

Second sheet called rank
=RANK(original!B2,original!$B2:$DPN2)
Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]

```
spmatrix import Matrix_100goede using Matrix_100goede, replace
spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR17, gs2sls dvarlag(Matrix_100goede) force
spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR17, gs2sls dvarlag(Matrix_100goede) force
```

**> € 100 mln**

```
clear
import excel "C:\Users\sterr\Documents\Master Real Estate Studies\Thesis\DATA\DATA_1000.xlsx", sheet("Sheet1") firstrow
destring _all, replace
gen lnCapVal = ln(Capital_value)
tab Foreign_local_Purchasersource_of, gen(ForeignLocalPurchaser)
tab Purchaser_broker_y_n , gen(BrokerYN)
gen lnAge = ln(Age)
gen lnSurface = ln(Surface)
tab Year, gen(YR)
tab Purchaser_type , gen(Purshasertypes)
tab Catherogy, gen(cat)
rename yr1 yr2000
rename yr2 yr2001
rename yr3 yr2002
rename yr4 yr2003
rename yr5 yr2004
rename yr6 yr2005
rename yr7 yr2006
rename yr8 yr2007
rename yr9 yr2008
rename yr10 yr2009
rename yr11 yr2010
rename yr12 yr2011
rename yr13 yr2012
rename yr14 yr2013
rename yr15 yr2014
rename yr16 yr2015
rename yr17 yr2016
rename yr18 yr2017
cd C:\Users\sterr\Documents
```

```
reg lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
reg lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18
assert Nummer
bysort Nummer: assert _N==1
spset Nummer,coord( Lat Long)
spset, modify coordsys(latlong,kilometers)
set matsize 11000
spmatrix create idistance Matrix_1000
spmatrix export Matrix_1000 using Matrix_1000
```

```
[EXPROT MATRIX TO EXCEL and edit to create correct matrix
First sheet called original with original matrix
Option Explicit
Sub deleteUpperTriangleMatrix()
Dim myRng As Range, i As Long, j As Long
Set myRng = ActiveCell.CurrentRegion
For j = 1 To myRng.Columns.Count
For i = 1 To j
myRng.Cells(i, j).ClearContents
Next i
Next j
End Sub
Second sheet called rank
=RANK(original!B2,original!$B2:$DPN2)
Third sheet called paste
=IF(rank!B2<6,original!B2,0)
Fourth sheet called weighted
=Paste!B2/SUM(Paste!$B2:$DPN2)
EXPORT to txt file for stata]
```

```
spmatrix import Matrix_1000goede using Matrix_1000goede, replace
spregress lnCapVal BrokerYN2 lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_1000goede) force
spregress lnCapVal i.BrokerYN2#c.Purchaser_market_share lnAge lnSurface Purshasertypes2-Purshasertypes8 cat1-cat5 YR2-YR18, gs2sls dvarlag(Matrix_1000goede) force
```