THE JOINT EFFECT OF ASYLUM SEEKER CENTERS ON SALE PRICES AND TIME ON THE MARKET IN THE NETHERLANDS

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Abstract. This thesis concerns an empirical analysis of the economic impact of asylum seeker centers (ASCs) on the housing market, as reflected in sale prices and time on the market. Data on house transactions and active ASCs over the last 25 years is analyzed using a two stage least squares (2SLS) method. The results show a clear and robust impact of ASCs on the housing market. Houses that are transacted within 1,000 meters of an active ASC experience a sale price discount of 10.3%, and have a 21.5% higher time on the market. Both effects diminish over distance. The effect on sale prices diminishes to a 4.8% decrease at 2,000 meters to the nearest active ASC. The effect on time on the market diminishes to a 4.9% increase at 2,000 meters to the nearest active ASC. Additionally, the presence of ASCs is associated with a higher time on the market. The results have strong implications for policy makers.

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PREFACE

Before you lies my master thesis 'The joint effect of asylum seeker centers on sale prices and time on the market in the Netherlands". This thesis was written during my internship at Ortec Finance to conclude the master Real Estate Studies at the University of Groningen. It therefore marks the end of my fantastic time as student, and my start in the real estate profession. I am looking forward to the exciting times that lie ahead.

I want to thank my supervisors Arno van der Vlist and Marc Francke for their helpful feedback during the writing of this thesis. I also owe gratitude to my friends, colleagues at Ortec Finance, and most importantly my family for their continued support, help, and interest. Some final thanks go to COA and NVM for providing the data that was necessary for the empirical analysis. I really appreciate all your contributions to the timely completion of this thesis.

I hope you enjoy your reading.

Marnix Uri

Amsterdam, September 26, 2017

Contents

1. INTRODUCTION

Asylum seeker centers (ASC) are locations that serve as shelter for refugees awaiting a definitive migration status (COA, 2017). There are currently circa 18,000 refugees in the Netherlands, sheltered in 160 ASCs (Vluchtelingenwerk, 2017). The presence of an ASC is highly contentious. For example, the small Dutch town Oudenbosch received national attention in 2015 when wealthy inhabitants bought a piece of land that was originally designated to establish a new ASC. The action effectively obstructed the plan of local policy makers to shelter roughly 750 refugees. The inhabitants were motivated by a concern that the value of their villas would diminish because of the ASC.

The case of Oudenbosch is one of many examples where residents tried to obstruct the arrival of a new ASC based on the economic argument of diminishing property values (NOS, 2017; Volkskrant, 2008). It is clearly of importance to policy makers whether this argument is valid. ASCs are a contentious topic. Considering the continued inflow of refugees resulting from the conflicts in the Middle East, ASCs will remain a relevant topic in the coming years (European Commission, 2016). Because of this, this thesis attempts to provide input for the decision-making process of policy makers. It does this by addressing the economic effects of ASCs on the housing market.

This study relates to the broad literature on negative externalities. It is widely accepted that amenities create external effects, and these are reflected in sale prices (Wilkinson, 1973; Cheshire & Sheppard, 1995). Many studies have found a negative effect of externalities on sale prices. For example, windmills causing visual pollution (Dröes & Koster, 2016), or airports causing noise (Theebe, 2004) will decrease the attractiveness of nearby houses. As a result, demand for these houses is lower, which has a diminishing effect on sale prices. It can be expected that ASCs cause a similar effect. ASCs are often reported to be associated with noise, crime, and estrangement in neighborhoods (Lubbers, Coenders & Scheepers, 2006; Kuppens & Ferwerda, 2016). However, an economic effect resulting from these negative externalities has not yet been found. Theebe (2002) studied their impact, but found no negative effects on the housing market[1]. Because of the growing amount of data on this subject, it appears worthwhile to actualize the study by Theebe (2002).

A second reason to analyze the effects of ASCs, is that a growing number of studies acknowledge the importance of time on the market as a market indicator, next to sale prices. The inclusion of time on the market has led to new insights in studies on the economic impact of externalities (Dubé & Legros, 2016). Clearly, there can be a considerable economic impact if a house is sold for a regular market price, but it takes longer for that price to be realized because of an externality. When analyzing the economic impact of externalities, studies are therefore increasingly looking at their joint effect on sale prices and time on the market (Dubé & Legros, 2016). Thus, the second contribution of this study is that it extends the relatively small amount of literature that emphasizes the joint relation between sale prices and time on the market.

The central focus of this study is the joint effect of ASCs on sale prices and time on the market. This effect is analyzed by applying a two stage least squares (2SLS) method to a combined dataset provided by the Dutch Association for Realtors (NVM) and the Agency for the Reception of Asylum Seekers (COA).

The rest of the thesis is organized as follows. Section 2 describes literature on the effect of amenities on local housing markets, the importance of time on the market, and the relation between sale price and time on the market. Section 3 describes the empirical strategy and models used in the analysis. The dataset will be discussed in chapter 4, and the results are presented in chapter 5. The results are concluded in chapter 6.

[1] The study period (1997-1999) was characterized by exceptionally high growth rates for house prices in the Netherlands. Theebe suggests that this might have obscured any negative effects caused by ASCs.

2. THEORETICAL FRAMEWORK

2.1 Externalities and housing markets

It is widely accepted that housing is a composite and heterogeneous good. Housing consumption is therefore based on the underlying characteristics of a property. These are not limited to characteristics of the structure itself, such as size and age, but also include characteristics determined by location (Wilkinson, 1973; Cheshire & Sheppard, 1995).

Historically, the value of the location of a property was considered as a reflection of the utility derived from its accessibility to a central location, like a market or a central business district (von Thünen, 1842; Alonso, 1964). This longstanding theory was based on the idea that households are willing to pay a premium for a favorable location to reduce travel costs. As urban economics progressed, other types of location-determined characteristics received attention. In particular, externalities caused by amenities have been argued to be important locational housing characteristics (Cheshire & Sheppard, 1995). It is thought that the utility derived from externalities reflects their impact on the wellbeing of urban populations (Brander & Koetse, 2011). The mechanism is basically the same as that of von Thünen (1842) and Alonso (1964), namely that households are willing to pay a premium to be close to externalities that provide positive utility.

Aside from this direct effect, Bruekner, Thisse and Zeno (1999) find a second reason for house price premiums near positive externalities. They argue that high income households have a higher marginal valuation of externalities than low income households. High income households will be more strongly attracted to positive externalities than low income households, and low-income households will be more willing to be close to negative externalities than high income households (*ceterus paribus*). As a result, areas with high income households tend to be near areas with high levels of positive amenities, and vice versa.

Following the reasoning that positive externalities have positive effects on housing markets, much research has been done on externalities that have a negative effect on wellbeing.

Externalities might negatively affect wellbeing through a variety of ways, such as noise, visual pollution, or crime. Airports are an example of an amenity that provide negative externalities. People dislike living close to airports, because of the noise disturbances they cause. As a result, demand for housing near airports is lower, which leads to a lower sale price (Theebe, 2004). Unsurprisingly, most studies on similar topics find that negative amenities lower nearby sale prices (for example: Hite, Chern, Hitzhusen & Randall, 2001; Dröes & Koster, 2016).

Central to this thesis is whether ASCs have a negative effect on housing markets. Such an effect may be expected if ASCs cause negative externalities. Lubbers et al. (2006) surveyed people in the Netherlands of various socio-economic groups about their attitudes towards ASCs. They found that attitudes towards ASCs are dependent on several individual and contextual characteristics. However, the results indicated a generally negative attitude towards ASCs for all socio-economic groups. In a case study on an ASC in Zutphen, Kuppens and Ferwerda (2016) find that negative attitudes towards ASCs are caused by an expectation that ASCs cause increases in crime and noise. They conclude that this expectation is mostly subjective, because the ASC did not cause an observed increase in crime and noise. These results indicate that ASCs might indeed cause negative externalities. However, in the only study so far on the effect of ASCs on sale prices, Theebe (2002) found no significant results.

2.2 The role of time on the market

The literature on externalities is traditionally focused on sale price effects. Studies that focus on sale prices assume that the housing market is a competitive market, where all information is available and efficiently processed. If the housing market is a competitive market, buyers and sellers have complete information on the effects of an amenity, and these effects are accurately reflected in sale prices. However, this assumption does not hold because the housing market is imperfect (Turnbull & Zahirovic-Herbert, 2007; Campbell, Giglio & Pathak, 2011). As a result, buyers and sellers need time to learn and process information about market conditions before it is reflected in sale prices. This provides a reason why sale prices are not a straightforward reflection of the effects of an amenity. It also makes time on the market a useful market indicator for analysis (Dubé & Legros, 2016).

The time on the market is affected by seller's motivations (Case & Shiller, 1990), and by uncertainty about the optimal list price for a house (Knight, 2002). When sellers are motivated to quickly sell their home, for example when they accept a job in a different city, they can actively influence the time on the market by setting a low list price (Glower, Haurin & Hendershott, 1988). In addition, sellers are loss averse (Hayunga & Pace, 2016). Sellers will set a high list price for their home if the expected sale price is below a desired amount, such as the purchasing price of the home or the outstanding mortgage amount (Genesove & Mayer, 2001). The desired sale price might be achieved, but this comes at the expense of a longer time on the market.

The second factor affecting the time on the market, is uncertainty about the optimal list price relative to the true market value of a home. This uncertainty can be affected by several factors. First, the sale price of comparable sold houses gives a good indication of the true market value of a house. When a house is particularly unique, there exist few comparable houses. Therefore, there is high uncertainty about the true market value associated with unique houses (Haurin, 1988). Second, the ratio between buyers and sellers provides a measure of liquidity in the housing market (Van Dijk & Francke, 2017). If there is a decrease in the amount of potential buyers, economic theory predicts a decrease in the market value. However, sellers will not directly observe a decrease in the amount of potential buyers. Sellers will therefore temporarily overestimate the true market value of their house (Case & Shiller, 1990; Genevose & Han, 2012). The time on the market is therefore primarily affected by the list price relative to the market value. This ratio is in turn affected by seller's motivations, a house's heterogeneity, and short-term changes in demand.

2.3 Sale prices and time on the market

When sale price and time on the market are considered in the same framework, it is important to consider their interrelation. It was explained in the previous paragraph that sale prices indirectly affect time on the market, through the relation between list price and market value. Conversely, it is accepted that time on the market affects sale prices. Again, this effect works through the relation between list price and market value. The effect of time on the market on sale prices is explained by two seemingly contradicting theories.

First, Lazear (1986) states that sellers do not know the optimal list price of their home. They can only learn about the maximum potential sale price of their property through the distribution of buyer's bids. If a property does not sell in a certain period, the seller may infer that the list price was too high relative to the unknown market value. The seller may then reduce the list price to increase the chance of sale in the next period. As a result, an increase in the time on the market has a negative effect on sale prices. Second, Lippman and McCall (1986) state that high list prices will lead to high sale prices. When the list price is high relative to the true market value, the number of interested buyers is low. However, a longer time on the market will increase the chance that an interested buyer arrives. As a result, that an increase in the time on the market has a positive effect on sale prices. An, Cheng, Lin, and Liu (2013) have tried to reconcile these contradicting theories. They state that Lazear (1986) and Lippman and McCall (1986) can both be correct, depending on market conditions. For strongly declining markets, an additional month of time on the market causes a 6.81% decrease of sale prices, because house prices and expected future bids will decline under such conditions. The effect of an additional month of time on the market on sale price becomes 1.61% positive for declining markets, followed by a 1.78% effect in a steady market, 3.79% in a growing market, 4.13% in a fast-growing market, and 7.5% in a rapidly growing market (An et al., 2013). Therefore, the literature predicts a relation between time on the market and sale prices that is either positive or negative, depending on market conditions.

In the context of externalities, it is helpful to consider that time on the market represents a cost to the seller. There are two ways time on the market represents costs. First, the seller may incur direct costs to a realtor or a listing site, which carry on over time. Second, sellers that are highly motivated to sell their home may consider time on the market as an indirect cost. In this context, sale prices and time on the market represent a trade-off. Motivated to achieve the highest possible net present value, a seller will want to maximize their income (sale price), while minimizing their costs (time on the market) in the selling process (Trippi, 1977). When analyzing the impact of externalities on this trade-off, the time on the market can be considered as the time until the effect of an externality is capitalized (Dubé & Legros, 2016). As such, a decrease in housing demand that results from the presence of a negative externality might affect sellers in two ways. First, it might reduce the potential sale price, and thus reduce the seller's income. Second, it might increase the time on the market, and thus increase the seller's costs. When studying the economic impact of amenities, it is thus necessary to consider time on the market and sale price of a house, rather than sale price alone (Belkin, Hempel & McLeavey, 1976; Dubé & Legros, 2016).

2.4 Hypotheses

The theoretical framework described above establishes the possible relation between ASCs and local housing markets. If ASCs are considered amenities that create negative externalities, we expect that this will be considered as a negative locational characteristic of nearby houses. We expect that this negative characteristic will result in a lower sale price and/or a longer time on the market. Furthermore, it is expected that the sale price and time on the market are related. It will therefore be appropriate to consider time on the market and sale price jointly, rather than separately. These expectations will be tested with the following hypotheses:

(1) Asylum seeker centers cause a negative effect on the sale price of nearby houses.

(2) Asylum seeker centers cause a positive effect on the time on the market of nearby houses.

3. METHODOLOGY

3.1 Hedonic analysis

Many studies about externalities find their roots in hedonic analysis (Rosen, 1974). Hedonic analysis allows for an estimation of the relative contribution of the underlying characteristics of heterogeneous goods on a dependent variable. That is to say, a good can be decomposed into a bundle of characteristics, and each of these characteristics can be implicitly valued by the market (Sheppard, 1999). Even though the characteristics are neither produced nor consumed individually, the composite values add to the total value of a property. This results in the specifications

$$SP = f(TOM, P, L, T, E), \tag{3.1}$$

where *SP* refers to sale price, *TOM* refers to time on the market, *P* refers to physical characteristics, *L* refers to locational characteristics, *T* refers to temporal characteristics, and *E* refers to a variable that reflects the presence of an externality, and

$$TOM = f(S, H, L, T, E), \tag{3.2}$$

where *TOM* refers to time on the market, *S* refers to seller's motivation, *H* refers to physical characteristics that affect a property's uniqueness, *L* refers to locational characteristics, *T* refers to temporal characteristics, and *E* refers to a variable that reflects the presence of an externality (Can, 1992; Springer, 1996; Glower et al., 1998).

The first category *P* refers to the structural characteristics of a property, such as the number of rooms or the presence of a garage. The variables underlying this category will be discussed in chapter 4. The second category of characteristics *L* refers to the properties of the location of a property. As stated in the section 2.1, these characteristics may include a variety of factors that are location-determined. Because of this broad definition, locational characteristics are often approximated using regional dummies (Theebe, 2002). The third category *T* refers to the temporal market conditions of a transaction. A variable that controls for economic conditions like inflation need to be included, to correct for distortions that occur in a dataset spanning multiple time periods. This correction is made with the addition of a dummy variable on a yearly by quarterly basis. The fourth category S refers to sellers' motivation to sell. If sellers are looking for a short time on the market, they will set a high list price relative to the market value (Glower et al., 1998). The seller's motivation is therefore approximated by the list price relative to the sale price. The fifth category H refers to the uniqueness of a house (Haurin, 1988). Uniqueness is controlled for by a variable reflecting irregular house types, and a variable indicating whether a house is luxurious. Finally, the sixth category E refers to a variable that indicates the source of an externality. According to Theebe (2002), such a variable can be specified with three methods. These methods are the inclusion of a dummy variable for presence, a variable reflecting distance, or a variable that can be specifically linked to the externality. This analysis will make use of range dummies. The ranges for the dummy variable are 0 – 1,000 meters, 1,000 – 2,000 meters, and more than 2,000 meters[2]. Following these category definitions, the hedonic equations for sale prices and time on the market are

$$\log(SP) = \alpha_1 + \beta_1 \log(TOM) + \beta_2 X_P + \beta_3 L + \beta_4 T + \beta_5 E + \varepsilon_1 \tag{3.3}$$

$$\log(TOM) = \alpha_2 + \beta_6 \log(S) + \beta_7 X_H + \beta_8 L + \beta_9 T + \beta_{10} E + \varepsilon_1 \, , \tag{3.4}$$

[2] Based on van Duijn, Rouwendal, and Boersema (2016). The impact of changing values for the ranges will be tested in the robustness section.

with

Log *(SP)*	Log of sale price
Log *(TOM)*	Log of time on the market
P	Logs and dummies of physical characteristics, specified in chapter 4
L	4-digit postal code dummy
T	Dummy for every quarter of every year
E	Dummy indicating 0-1,000, 1,000-2,000, or more than 2,000 meters to the nearest ASC
Log *(S)*	Original list price relative to expected sale price *SP*
H	Dummy indicating unusual house types and a dummy indicating luxury.

From equations 3.3 and 3.4 it appears that the Gauss-Markov assumptions[3] will be violated if log (*SP*) and log (*TOM*) are estimated using ordinary least squares (OLS). This is because log (*SP*) appears as dependent variable in 3.3, and as independent variable via log(*S*) in 3.4. Likewise, log (*TOM*) appears as independent variable in 3.3, and as dependent variable in 3.4. Recall that the Gauss-Markov assumptions state that X_i and ε_i need to be independent of one another. Rewriting this formal statement leads to

$$E(X'\varepsilon) = 0. \qquad (3.5)$$

Because log (*TOM*) and log (*SP*) appear in equations 3.3 and 3.4, equation 3.5 will not hold (Brooks & Tsolacos, 2010). If equation 3.5 is violated, it is said that the regressors are endogenous. When a regressor is endogenous, OLS will attribute variation in Y_i to X_i, even though this variation is truly caused by variations in ε_i. X_i will therefore 'capture' some information that should really be reflected in the error term. In other words, the OLS regression will not lead to the best linear unbiased estimator (BLUE), and the results will not be valid.

[3] The Gauss-Markov assumptions are listed in Appendix A.

3.2 Addressing endogeneity

The endogenous relation between sale price and time on the market needs to be addressed to produce valid results. Two stage least squares (2SLS) models are commonly used to address such relations. The goal of a 2SLS method is to solve the endogeneity problem, by obtaining a valid replacement for the endogenous variables. This is done in two stages. First, the exogenous variables are regressed on instrumental variables and a number of independent variables. Second, the predicted values from the first stage are used as independent variables in the second stage equation. The goal of the 2SLS approach is to obtain an instrumental variable that is not correlated with ε as proxy for the endogenous variable. This is done in the first stage. Because the predicted value does not contain the endogenous variable, it is of full rank. In other words, the predicted value does not suffer from multicollinearity, because it is not correlated with the dependent variable in the second stage. However, the predicted value will be highly correlated with the endogenous variable it is replacing, which makes it a valid instrument. As a result, the second stage equations will be regressed on a matrix of exogenous variables.

The 2SLS method has been applied by researchers in the context of sale prices and time on the market, such as Cubbin (1974), and Asabere, Huffman, and Mehdian (1994). They partly adopt a 2SLS model in which the first stage estimation of time on the market is used as an exogenous variable in the second stage estimation of sale prices. However, the first stage estimation of sale price is not used as exogenous variable in a second stage estimation on time on the market. These studies therefore only partly address the endogenous relation, because only one equation is finally estimated.

Knight (2002) was the first to apply a full 2SLS model to sale prices and time on the market. This method has become the standard for studies in this context. In Knight (2002), sale price and time on the market are both estimated in the first stage. The predicted values were then used in either equation in the second stage. Knight's method is therefore preferred over the methods from Cubbin (1974) or Asabere et al. (1994), because sale price and time on the market are both finally estimated. When equations 3.3 and 3.4 are adapted to this method, the following first stage equations are specified

$$\log(SP_1) = \alpha_1 + \beta_1 X_P + \beta_2 L + \beta_3 T + \varepsilon_1 \tag{3.6}$$

$$\log(TOM_1) = \alpha_2 + \beta_4 \log(S_1) + \beta_5 X_H + \beta_6 L + \beta_7 T + \varepsilon_2\ , \tag{3.7}$$

Where log (SP_1) is regressed on the same P, L, and T as in section 3.1. Log (TOM_1) is regressed on the same H, L, and T as in section 3.1, but log (S_1) is now defined as the original list price relative to log (SP_1). The second stage equations can be estimated using the following specifications, based on Knight (2002)[4].

$$\log(SP_2) = \alpha_3 + \beta_8 \log(TOM_1) + \beta_9 X_P + \beta_{10} L + \beta_{11} T + \beta_{12} E + e_1 \tag{3.8}$$

$$\log(TOM_2) = \alpha_4 + \beta_{13} \log(S_2) + \beta_{14} X_H + \beta_{15} L + \beta_{16} T + \beta_{17} E + e_2 \tag{3.9}$$

In equation 3.8, log (SP_2) is regressed on the same independent variables as log (SP_1) in equation 3.6, with the addition of log (TOM_1) and E. Log (TOM_1) represents the predicted value from equation 3.7, and functions as the exogenous instrumental variable for the second stage estimation of sale price. E represents a dummy variable for the presence of an ASC within certain ranges, as discussed in section 3.1. In equation 3.9, log (TOM_2) is regressed on the same independent variables as log (TOM_1) in equation 3.7, with addition of E. Log (S_1) is replaced with log (S_2), which is defined as the original list price relative to log (SP_2). Log (S_2) functions as the exogenous instrumental variable for the second stage estimation of time on the market.

[4] There exist other statistical methods that address the endogenous relation between sale prices and time on the market. Examples include a joint log likelihood method (Horowitz, 1992; Huang & Palmquist, 2001), a different specification of the 2SLS-method (Turnbull, Dombrow & Sirmans; 2006), or the implementation of a spatiotemporal matrix W in the 2SLS-method (Dubé & Legros, 2016). The approach by Knight (2002) was adopted for this study, because of its practical application and because it has been the standard method for studies in this context.

4. DATA

4.1 Dataset

The dataset used in this analysis consists of data from the Agency for the Reception of Asylum Seekers (COA) and data from the Dutch Association for Realtors (NVM). The combined dataset contains extensive information on housing transactions and ASCs in the Netherlands.

The complete NVM dataset covers roughly 75% of all housing transactions in the Netherlands. It is widely used in scientific research because it is assumed to be representative of the entire Dutch housing market, and because of the large amount of information on each observation. Because the full NVM dataset is hardly ever distributed, this analysis uses a pre-selected subset. The subset contains information on transactions between January 1st, 1992 and December 31st, 2016 within 36 municipalities in the Netherlands.

The selection of municipalities was based on the presence of an active ASC. A municipality was selected if it contains an active ASC. If an active ASC is roughly within 1.5 kilometer of a border of a municipality, the adjacent municipality is also selected. This is done to account for any effects that surpass administrative borders. The selection of municipalities was limited by the NVM, so that only municipalities containing or adjacent to ASCs with a capacity larger than 250 beds could be selected. This restriction does not appear to be problematic, because the possible effects of ASCs increase with size (Lubbers et al., 2006). The list of selected municipalities can be found in Appendix B.

The resulting dataset contains 70 variables on sale conditions, structural characteristics, and location of 796,077 observations. Based on Theebe (2002), a selection is made of the variables that will be used for this analysis (table 1).

Table 1. Property specific attributes (NVM, 2017)

Attribute class	Variable	Description
Transactional	Sale price	Nominal sale price
	Original list price	Initial nominal list price
	List price premium	Relative difference between original list price and sale price
	Time on the market	Number of days on the market
	Date of sale	Dummy for quarter of sale
Structural	House area	Corrected useable living area in m^2
	Maintenance	Dummy for maintenance quality (1 = good)
	Monument	Dummy for monumental status (1 = yes)
	Balcony	Dummy for balcony (1 = yes)
	Garage	Dummy for garage (1 = yes)
	Terrace	Dummy for terrace (1 = yes)
	Central heating	Dummy for central heating (1 = yes)
	Building period	Categorical variable for building period
	Property type	Categorical variable for various house and apartment types
Locational	Municipality	Categorical variable for municipality
	ZIP Code	4- and 6-digit ZIP-codes

The dataset from COA contains information on all 160 active ASCs in the Netherlands. It provides information on the location, size, type, opening date and (if applicable) closing date of each center (table 2). A shortcoming of this dataset is the missing of inactive centers. If an ASC was once active, but is no longer considered an active ASC, it is not included in this dataset. Because of this, there are relatively few ASCs present in the dataset that opened more than five years ago. The result is that no house transactions could be included that occurred near inactive ASCs. It is assumed in this study that the effects of ASCs are unidirectional in time, so that a transaction is not affected by an ASC that has not been opened yet. This is accounted for with the help of a control variable that indicates if a transaction took place after the opening of the nearest ASC.

Table 2. ASC specific attributes (COA, 2017)

Variable	Description
Location	Street name and house number
Postcode	Six-digit postal code
Capacity	Number of available beds
Opening date	First night in use
Closing date	Last night in use

The selected variables were prepared for statistical analysis by log-transformation, and by removing outliers, implausible values, and cases that had missing values on key variables. Additionally, the dataset was geo-referenced using RD-coordinates[5]. This system provides latitudes, longitudes and coordinates for all house transactions and ASCs based on their 6-digit postal codes. Using Pythagoras' theorem, the Euclidian distance between each house to the nearest ASC was calculated. The trimmed dataset contains structural characteristics, date of sale, time on the market, location, and distance to the nearest ASC for 544,788 unique transactions. The full technical data preparation process is described in Appendix C.

4.2 Descriptive statistics

Transaction details and the number of observations of four subsamples are presented in table 3. The subsamples are made to illustrate differences between transactions, based on whether they occurred before the opening of the nearest ASC, and whether the nearest ASC was within 2,000 meters.

Table 3 shows that 90.3% of transactions occurred before the opening of the nearest ASC. The average transaction date is roughly six years earlier than transactions that occurred after the nearest ASC was opened. Furthermore, table 3 shows that houses transacted before the opening of the nearest ASC have a sale price that is roughly 13,000 euros lower, compared to transactions that occurred after opening of the nearest ASC. The time on the market is roughly 50 days shorter for these transactions. Considering the difference in median transaction date, it is expected that the differences in sale price and time on the market are mostly caused by market conditions, rather than caused by the opening of an ASC. The difference in median transaction date can be

[5] The RD-system (Rijksdriehoekscoördinaten) is the most widely used basis for geo-referencing in the Netherlands. It was applied with the help of an SQL-script provided by Ortec Finance.

explained by the fact that most of the ASCs in the COA dataset opened within the last five years. It then follows that transactions that occurred after the opening of an ASC mostly occurred in the last five years. This feat causes some selection bias. Because many transactions occurred in the period 2012-2016, a period of house price recovery after the financial crisis, it is possible that these particular economic conditions affect the results. However, selection bias is not considered problematic for this study due to the inclusion of a variable controlling for time fixed effects, and because of the large number of observations in the dataset.

Furthermore, table 3 shows that 80% of transactions occurred farther than 2,000 meters from the nearest ASC. The average sale price is roughly 25,000 euros higher for these transactions, and the time on the market is slightly lower. The difference in sale price between the groups stays equal after the opening of the nearest ASC, whereas the difference in time on the market increases. Because of the large difference in market conditions between the groups, it cannot be concluded that the differences in sale price and time on the market are caused by ASCs. This issue will be addressed in the robustness section of the next chapter.

Table 3. Number of observations and market indicators per subsample

		ASC within 2,000 meters	ASC farther than 2,000 meters
Transaction before opening of nearest ASC	Observations	82,318	409,629
	Median transaction date	November 26th, 2004	August 4h, 2005
	Sale price	180,206	204,359
	Time on the market	127.65	124.18
Transaction after opening of nearest ASC	Observations	9,627	43,214
	Median transaction date	April 1st, 2011	April 14th, 2011
	Sale price	192,687	217,559
	Time on the market	185.17	170.58

The full descriptive statistics of the dataset are presented in table 4. Observations are divided based on the distance to the nearest ASC[6]. All variables in table 4 show reasonable values

[6] Frequency tables for different ASC distances are presented in Appendix D

for the total dataset. The average transaction corresponds to a sale price of 201,553 euro, with a 5.59% list price premium, a time to sell of 129 days (roughly 4.3 months), and a distance to the nearest ASC of 5,133 meters. The difference between the target group and the control group is remarkable. The means of these groups are significantly different from one another for virtually all variables. Most notably, the sale price is 24,109 euros lower, the list price premium 0.46% higher, and the time on the market five days longer for the target group, compared to the control group. Because of the large structural differences between the groups, such as the newer building periods in the control group, it cannot be concluded that the differences in sale price, list price premium, and time to sell are due to the presence of an ASC. One thing that can be concluded is that the location of ASCs is not random. If they were random, it would be expected that the target group and control group were roughly similar. The difference in characteristics between the target group and the control group can indicate two things. First, it may be the case that ASCs are allocated to places that are characterized by lower sale prices and higher time on the market. Second, it may be the case that ASCs cause lower sale prices and higher time on the market. This will be addressed in the section 5.2.

Table 4. Descriptive statistics target group, control group and total

	ASC within 2,000 meters (Target group)		ASC farther than 2,000 meters (Control group)		Total		Δ Target - Control
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean
Sale price	181,513	94,828	205,622	123,556	201,553	119,535	-24,109***
List price	192,504	102,373	216,889	131,201	212,773	127,125	-24,385***
List price premium	.0597	.069647	.0551	.070261	.0559	.07018	.0046***
Time on the market	133.67	191.42	128.61	184.39	129.46	185.6	5.06***
Distance to ASC	1336.8	448.52	5903.3	3667.5	5132.6	3760.3	-4,566.5***
House Area	109.98	34.166	108.05	37.721	108.38	37.152	1.93***
Maintenance (1 = Good)	.17619	.38099	.18969	.39205	.18741	.39024	-.0135***
Monument (1 = Yes)	.0038284	.061756	.012731	.11211	.011228	.10537	-.008903***
Balcony (1 = Yes)	.31892	.46606	.35207	.47762	.34647	.47585	-.03315***
Garage (1 = Yes)	.22735	.41912	.18517	.38844	.19229	.3941	.04218***
Terrace (1 = Yes)	.062168	.24146	.078389	.26878	.075651	.26444	-.016221***
Central heating (1 = Yes)	.9795	.14171	.97252	.16348	.9737	.16004	.00698***
Building period 1500 - 1905	.031029	.1734	.069682	.25461	.063159	.24325	-.038653***
Building period 1906 - 1930	.13867	.3456	.13964	.34661	.13947	.34644	-.00097***
Building period 1931 - 1944	.094915	.2931	.092396	.28958	.092821	.29018	.002519***
Building period 1945 -1959	.087813	.28302	.066771	.24963	.070323	.25569	.021042***
Building period 1960 - 1970	.20944	.40691	.12921	.33543	.14275	.34982	.08023***
Building period 1971 - 1980	.15155	.35858	.13572	.34249	.13839	.34531	.01583***
Building period 1981 - 1990	.13008	.33639	.1472	.3543	.14431	.3514	-.01712***
Building period 1991 - 2000	.11904	.32384	.15691	.36372	.15052	.35758	-.03787***
Building period > 2001	.037468	.18991	.062474	.24202	.058254	.23422	-.025006***
House type: Single family	.52876	.49917	.42423	.49423	.44187	.49661	.10453***
House type: Canal house	.000087	.0093275	.0015767	.039676	.0013253	.03638	-.00149***
House type: Mansion	.074425	.26246	.0731	.2603	.073324	.26067	.001325***
House type: Farm	.0021861	.046705	.0046263	.06786	.0042145	.064782	-.00244***

Table 4. Descriptive statistics target group, control group and total (continued)

	ASC within 2,000 meters (Target group)		ASC farther than 2,000 meters (Control group)		Total		Δ Target - Control
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean
House type: Bungalow	.023025	.14998	.019007	.13655	.019685	.13891	.004018***
House type: Villa	.015433	.12327	.014513	.11959	.014668	.12022	.00092***
House type: Country house	.0033172	.0575	.0036724	.060489	.0036124	.059995	-.000355***
House type: Estate	0	0	.0000199	.004458	.0000165	.0040645	-1.99E-05
House type: Downstairs house	.044353	.20588	.060098	.23767	.057441	.23268	-.015745***
House type: Upstairs house	.067954	.25167	.17605	.38086	.15781	.36456	-.108096***
House type: Maisonette	.024439	.15441	.031653	.17508	.030436	.17178	-.007214***
House type: Flat	.11186	.3152	.11209	.31548	.11205	.31543	-.00023***
House type: Apartment	.09733	.29641	.074006	.26178	.077942	.26808	.023324***
House type: Hospice	.0040785	.063733	.0010821	.032877	.0015878	.039815	.0029964***
House type: Down- and upstairs house	.0027516	.052384	.0042752	.065245	.0040181	.063261	-.001524***
Number of observations	91,945		452,843		544,788		

Note: the rightmost column presents the difference between the means of the target group and the control group, calculated using a mean comparison t-test, With ***, **, * indicating significance at 1%, 5% and 10%, respectively.

5. RESULTS

5.1 Empirical results

This section reports the results from the 2SLS estimation on sale price (table 5) and time on the market (table 6).

In table 5, models 1, 2, and 3 correspond to equation 3.6, partial equation 3.8 without *E*, and full equation 3.8 including *E*, respectively. The full estimation results are reported in Appendix E. Model 1 presents the results for the restricted sale price model. This model represents the first stage equation of the 2SLS method, wherein the exogenous proxy is generated that is used in the second stage equations. In model 1, the log of sale price is regressed on a number of structural characteristics, temporal characteristics, and locational characteristics. The adjusted R_2 in model 1 is 0.873, meaning that the standard OLS can explain most of the variation in sale prices.

In model 2, the predicted TOM_1 from the first stage time on the market estimation (model 4) is added. The addition of the predicted TOM_1 leads to an improvement in explanatory power, compared to model 1. The TOM_1 variable is significant at the 1% level and negative (-0.0559). The log-log relation can be interpreted as a decrease in sale price of 0.06% when time on the market increases with 1%. In our dataset, a 25% increase corresponds to a one month increase in time on the market. Thus, a one month increase in the time on the market corresponds to a negative effect on the sale price of 1.5%. This finding relates to An et al. (2013), who predict a negative effect of 6.81% for one additional month of time on the market on sale price in rapidly declining markets, and a positive effect of 1.61% in declining markets. On average, the Dutch housing market experienced growth in the period 1992 – 2016. The estimated effect of time on the market on sale price in this study is therefore not explained by An et al. (2013). It also contradicts Lippman and McCall's (1986) theory, who predicted a positive effect of time on the market on sale price. It does confirm the theory of Lazear (1986), who predicted a negative effect of time on the market on sale price, although he did not indicate how strong this effect might be. In addition to this finding, model 2 shows changes in the parameter coefficients of the structural characteristics due to the inclusion of the TOM_1 variable. This may indicate endogeneity between TOM_1 and the structural characteristics, or it may indicate that model 1 suffered from omitted variable bias.

In model 3, dummies indicating the presence of ASCs are added. Compared to model 2, the addition of these dummies does not noticeably affect the model's explanatory power, although all coefficients are significant at the 1% level and negative. The coefficients show a nice property, namely that the negative effect of ASCs on sale prices appears to diminish when a house is transacted further away from ASCs. The sale price effect ranges from -10.3% within 1,000 meters of the nearest ASC to -4.8% for properties that are farther than 2,000 meters away from the nearest ASC. For a mean transaction in the dataset of 200,000 euro, being within 1,000 meters of an ASC leads to a decrease in sale price of 20,600 euro compared to a similar transaction in the control group. This finding corresponds to the difference that was indicated in the descriptive statistics (table 3), and confirms the hypothesis that ASCs negatively affect sale prices.

In table 6, models 4, 5, and 6 correspond to equation 3.7, partial equation 3.9 without E, and full equation 3.9 including E, respectively. Model 4 presents the results for the restricted time on the market model. This model represents the first stage equation of the 2SLS method, wherein the exogenous proxy is generated that is used in the second stage equations. In model 4, the log of time on the market is regressed on a number of structural characteristics, list price premium, temporal characteristics, and locational characteristics. The adjusted R_2 is 0.399, meaning that the restricted model explains 40% of the variation in time on the market. Studies on time on the market hardly exceed an R_2 of 15%, because time on the market is notoriously difficult to estimate (Knight, 2002; Dubé & Legros, 2016). Therefore, the R_2 in this estimation is very high. It is likely that this is caused by list price premium_1, which takes a parameter coefficient of 10.09.

In model 5, list price premium_1 is replaced by list price premium_2, which is the list price relative to the predicted market value from model 2. The R_2 drops to 18.3% after this change, which is normal compared to other studies (for example, Knight, 2002; Dubé & Legros, 2016). List price premium_2 is significant at the 1% level and strongly positive (1.157). The log-log relation can be interpreted as a 1.157% increase in the time to sell if the list price premium increases with 1%. The direction of this finding is consistent with the literature (Knight, 2002), although the size of the effect is greater than expected. Knight (2002) finds a positive effect of circa 0.2% of an increase of the list price premium on time on the market. In addition, a substantial change in parameter values for the structural characteristics in model 5 is observed, compared to model 4. The coefficient of *Monument* becomes significant, the coefficient for *Luxurious* becomes insignificant, and the coefficient for *Unique* triples in value. Similar results appear in Knight (2002). The change in coefficients is caused by the exclusion of list price premium$_1$, and the inclusion of list price premium$_2$. Considering the size of the coefficient of list price premium$_1$ in model 4, it is likely that this variable captures some information that was in fact caused by some other variable, like *Unique*. Given the exogenous nature of list price premium$_2$, it is expected that the coefficients in model 5 are more reflective of their true value.

In model 6, dummies indicating ranges to the nearest ASC are added. Compared to model 5, the model performance does not noticeably improve, although all coefficients are significant at the 1% level and positive. Like the sale price estimations, the dummy coefficients show a diminishing effect of ASCs on the time on the market for houses that are transacted farther away from ASCs. The time on the market effect ranges from 21.5% within 1,000 meters of the nearest ASC to an increase of 4.9% for properties farther than 2,000 meters from the nearest ASC. For a mean transaction with a time on the market of 129 days, being within 1,000 meters of the nearest ASC, increases the time on the market with roughly 28 days, compared to a similar transaction in the control group. This finding is much stronger than expected based on the descriptive statistics (table 3), but it does confirm the hypothesis that ASCs increase time on market.

Table 5. 2SLS sale price estimates

	Model 1	Model 2	Model 3
Variables	Restricted model	Partial second stage	Second stage + ASC
TOM_1		-0.0559***	-0.0556***
		(0.000409)	(0.000409)
ASC within 0 – 1,000 meters			-0.103***
			(0.00423)
ASC within 1,000 – 2,000 meters			-0.0696***
			(0.00264)
ASC farther than 2,000 meters			-0.0476***
			(0.00158)
Area	0.744***	0.753***	0.753***
	(0.00107)	(0.00106)	(0.00106)
Maintenance [1 = Good]	0.0802***	0.0786***	0.0787***
	(0.000676)	(0.000664)	(0.000663)
Monument (1 = Yes)	0.0926***	0.0918***	0.0913***
	(0.00253)	(0.00249)	(0.00249)
Balcony (1 = Yes)	0.0216***	0.0201***	0.0200***
	(0.000686)	(0.000675)	(0.000674)
Garage (1 = Yes)	0.132***	0.137***	0.137***
	(0.000779)	(0.000767)	(0.000766)
Terrace (1 = Yes)	0.0526***	0.0528***	0.0528***
	(0.000997)	(0.000980)	(0.000979)
Central heating (1 = Yes)	0.0340***	0.0339***	0.0335***
	(0.00156)	(0.00153)	(0.00153)
Building period fixed effects	*Yes*	*Yes*	*Yes*
House type fixed effects	*Yes*	*Yes*	*Yes*
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	9.463***	9.615***	9.663***
	(0.00659)	(0.00658)	(0.00671)
Observations	544,788	544,788	544,788
Adjusted R-squared	0.873	0.877	0.877
Joint sig. F test	4743	4923	4919
RMSE	0.182	0.179	0.179

Note: The dependent variable is log of sale price. The reference category is a single-family house that was built after 2001, transacted in Q4 2016, located in Amsterdam, with no ASC treatment. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

Table 6. 2SLS Time on the market estimation results

	Model 4	Model 5	Model 6
Variables	Restricted model	Partial second stage	Second stage + ASC
List price premium1	10.09***		
	(0.0213)		
List price premium2		1.157***	1.161***
		(0.00786)	(0.00786)
ASC within 0 – 1,000 meters			0.215***
			(0.0256)
ASC within 1,000 – 2,000 meters			0.155***
			(0.0160)
ASC farther than 2,000 meters			0.0488***
			(0.00959)
Monument (1 = Yes)	0.0168	0.0411***	0.0416***
	(0.0128)	(0.0149)	(0.0149)
Unique (1 = Yes)	0.00247**	0.00741***	0.00735***
	(0.000984)	(0.00115)	(0.00115)
Luxurious (1 = Yes)	0.105***	-0.000707	-0.00110
	(0.00534)	(0.00627)	(0.00627)
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	3.596***	3.506***	3.445***
	(0.0180)	(0.0210)	(0.0226)
Observations	544,788	544,788	544,788
Adjusted R-squared	0.399	0.183	0.183
Joint sig. F test	473.4	160.4	160
RMSE	0.931	1.086	1.086

Note: The dependent variable is log of time on the market. The reference category is a transaction that occurred in Q4 2016, located in Amsterdam, with no ASC treatment. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

5.2 Robustness

This section discusses the robustness of the reported results. First, the effect of changes in the range category for the distance to nearest ASC are reported in table 7 and 8. Next, estimation results for the observations that received no treatment are reported in table 9 and 10.

Table 7 shows the effect of different measures for the presence of an ASC on sale prices. The model specification in table 7 is exactly equal to model 3, but not all variables are reported here. The full estimation results can be found in Appendix F.1. Table 7 shows that the coefficients slightly change for each specification of the range categories, but the overall results are very similar to the initial findings. Within the closest proximity, a negative sale price effect of roughly 10% is found. The effect initially becomes smaller over distance, to a minimum of 5% for transactions farther than 2,000 meters from the nearest ASC. Additionally, model 9 shows the effect of a linear and quadratic indicator for the presence of ASCs, as proposed by Theebe (2002). The coefficient for the linear effect shows that sale prices become lower, farther away from an ASC. The coefficient for the quadratic effect shows that the linear effect slows down, but at a very slow rate, due to the small size of the quadratic coefficient. These results contradict the initial findings, without an immediately apparent explanation. However, the coefficients for the range categories confirm the robustness of the initial results.

Table 8 shows the effect of different measures for the presence of an ASC on time on the market. The model specification in table 8 is exactly equal to model 6, but not all variables are reported here. The full estimation results can be found in Appendix F.2. Table 8 shows that the results slightly change for each specification of the range categories, but the overall results are very similar to the initial findings. Within the nearest proximity, a positive time on the market effect in the range of 20 – 30% is found. The effect becomes smaller over distance, to a minimum of 3.8% for transactions farther than 3,000 meters from the nearest ASC. Additionally, model 12 shows the effect of a linear and quadratic indicator for the presence of ASCs. The coefficient for the linear effect shows that time on the market become higher, farther away from an ASC. The coefficient for the quadratic effect is not significant, meaning that the linear effect does not diminish over distance. These results contradict the initial findings, without an immediately apparent explanation. It is remarkable that the coefficients for the linear and quadratic distance variable behave similarly in models 9 and 12. This may indicate a misspecification of these variables, although this cannot be concluded with certainty. However, the coefficients for the range categories confirm the robustness of the initial findings.

Table 7. Robustness analysis for alternative ASC ranges on sale price

Variables	Model 7 Second stage sale price with ASC categories: 0 – 750 750 – 1,500 1,500 – 3000 3,000 – max	Model 8 Second stage sale price with ASC categories: 0 – 500 500 – 2,000 3,000 – max	Model 9 Second stage sale price with linear and quadratic ASC distances
TOM_1	-0.0556***	-0.0556***	-0.0559***
	(0.000409)	(0.000409)	(0.000409)
ASC within 0 – 750 meters	-0.0904***		
	(0.00561)		
ASC within 750 – 1,500 meters	-0.0903***		
	(0.00327)		
ASC within 1,500 – 3,000 meters	-0.0574***		
	(0.00211)		
ASC farther than 3,000 meters	-0.0447***		
	(0.00171)		
ASC within 0 – 500 meters		-0.0948***	
		(0.00991)	
ASC within 500 – 2,000 meters		-0.0761***	
		(0.00249)	
ASC farther than 2,000 meters		-0.0477***	
		(0.00158)	
ASC linear distance			-8.87e-06***
			(6.61e-07)
ASC quadratic distance			2.45e-10***
			(0)
Structural characteristics	*Yes*	*Yes*	*Yes*
Building period fixed effects	*Yes*	*Yes*	*Yes*
House type fixed effects	*Yes*	*Yes*	*Yes*
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	9.662***	9.662***	9.671***
	(0.00671)	(0.00671)	(0.00773)
Observations	544,788	544,788	544,788
Adjusted R-squared	0.877	0.877	0.877
Joint sig. F test	4913	4919	4913
RMSE	0.179	0.179	0.179

Note: The dependent variable is log of sale price. The reference category is a single-family house that was built after 2001, transacted in Q4 2016, located in Amsterdam, with no ASC treatment. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

Table 8. Robustness analysis for alternative ASC ranges on time on the market

Variables	Model 10 Second stage sale price with ASC categories: 0 – 750 750 – 1,500 1,500 – 3000 3,000 – max	Model 11 Second stage sale price with ASC categories: 0 – 500 500 – 2,000 3,000 – max	Model 12 Second stage sale price with linear and quadratic ASC distances
List price premium2	1.161***	1.161***	1.158***
	(0.00786)	(0.00786)	(0.00786)
ASC within 0 – 750 meters	0.261***		
	(0.0340)		
ASC within 750 – 1,500 meters	0.141***		
	(0.0198)		
ASC within 1,500 – 3,000 meters	0.108***		
	(0.0128)		
ASC farther than 3,000 meters	0.0382***		
	(0.0104)		
ASC within 0 – 500 meters		0.296***	
		(0.0601)	
ASC within 500 – 2,000 meters		0.164***	
		(0.0151)	
ASC farther than 2,000 meters		0.0491***	
		(0.00959)	
ASC linear distance			2.27e-05***
			(4.00e-06)
ASC quadratic distance			-1.77e-10
			(1.77e-10)
Structural characteristics	*Yes*	*Yes*	*Yes*
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	3.446***	3.444***	3.338***
	(0.0226)	(0.0226)	(0.0319)
Observations	544,788	544,788	544,788
Adjusted R-squared	0.183	0.183	0.183
Joint sig. F test	159.8	160	160.1
RMSE	1.086	1.086	1.086

Note: The dependent variable is log of time on the market. The reference category is a transaction that occurred in Q4 2016, located in Amsterdam, with no ASC treatment. All models include structural variables, fixed effects and list price premium2, equal to Model 6. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

In the section about descriptive statistics, it was suggested that ASCs may be placed in locations that are characterized by low sale prices and high time on the market. If this is the case, the initial findings cannot prove a causal effect of ASCs. To control for this possibility, models 1 through 6 are estimated on a subset of the dataset. The subset represents transactions that occurred at least 1,000 days before the nearest ASC was opened. It appears reasonable to assume that transactions are not affected by ASCs that open roughly three years after the transaction, because it is unlikely that there would be knowledge about the future presence of an ASC. These estimations therefore serve as falsification; if the coefficients are significant for this subsample, a causal effect of ASCs on sale prices and time on the market cannot be concluded. If the coefficients are insignificant, it strengthens the conclusion that the initial results are caused by ASCs, and not by a different unknown variable.

Table 9 and 10 show the estimation results for the sale price and time on the market estimations on transactions that occurred 1,000 days before the opening of their respective nearest ASC. Full results for the sale price estimation can be found in Appendix F.3. It should be noted that the reference category consists of transactions that occurred more than 2,000 meters away from the nearest ASC. This is different than the initial estimations, where houses that were transacted before the opening of the nearest ASC were used as reference category. For obvious reasons, this reference category would be nonsensical on this subsample.

In table 9, models 13, 14, and 15 correspond to equation 3.6, partial equation 3.8 without E, and full equation 3.8 including E, respectively. The estimation results in model 13 and 14 are very similar to the initial findings. All coefficients and model performance indicators have similar values as the initial estimations, except for the F-test. The difference in F-statistic can be attributed to the lower number of observations used in these estimations. In model 15, the range categories to the nearest ASC are added. The coefficients are insignificant for all categories. This indicates the robustness and causality of the initial results, that ASCs negative affect sale prices.

Table 9. 2SLS sale price estimates on non-treatment observations

	Model 13	Model 14	Model 15
Variables	Restricted model	Partial second stage	Second stage + ASC
TOM_1		-0.0444***	-0.0444***
		(0.000737)	(0.000737)
ASC within 0 – 1,000 meters			-0.00519
			(0.00403)
ASC within 1,000 – 2,000 meters			-0.00227
			(0.00252)
Area	0.785***	0.790***	0.790***
	(0.00222)	(0.00219)	(0.00219)
Maintenance [1 = Good]	0.0902***	0.0884***	0.0884***
	(0.00151)	(0.00149)	(0.00149)
Monument (1 = Yes)	0.0657***	0.0644***	0.0644***
	(0.00526)	(0.00518)	(0.00518)
Balcony (1 = Yes)	0.0252***	0.0243***	0.0243***
	(0.00153)	(0.00151)	(0.00151)
Garage (1 = Yes)	0.129***	0.134***	0.134***
	(0.00156)	(0.00154)	(0.00154)
Terrace (1 = Yes)	0.0437***	0.0454***	0.0454***
	(0.00197)	(0.00195)	(0.00195)
Central heating (1 = Yes)	0.0206***	0.0216***	0.0216***
	(0.00361)	(0.00356)	(0.00356)
Building type fixed effects	*Yes*	*Yes*	*Yes*
House type fixed effects	*Yes*	*Yes*	*Yes*
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	9.464***	9.570***	9.570***
	(0.0132)	(0.0131)	(0.0131)
Observations	121,242	121,242	121,242
Adjusted R-squared	0.865	0.869	0.869
Joint sig. F test	1000	1034	1031
RMSE	0.181	0.179	0.179

Note: The dependent variable is log of sale price. The reference category is a single-family house that was built after 2001, transacted in Q4 2016, located in Amsterdam, with a hypothetical nearest ASC distance farther than 2,000 meters. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

In table 10, models 16, 17, and 18 correspond to equation 3.7, partial equation 3.9 without E, and full equation 3.9 including E, respectively. The estimation results in model 16 and 17 are very similar to the initial findings, except for the F-test. In model 18, the range categories to the nearest ASC are added. The coefficients for transactions within the range 0 – 1,000 meters and 1,000 – 2,000 meters are significant at the 10% and 5% level, respectively. This indicates a weak positive effect of the location of these transactions on the time on the market. The time on the market in locations near ASCs is higher than locations farther away. Therefore, there exists a level of association between the presence of ASCs and time on the market, but it cannot be strictly concluded that ASCs cause this effect.

Table 10. 2SLS time on the market estimates on non-treatment observations

	Model 16	Model 17	Model 18
Variables	Restricted model	Partial second stage	Second stage + ASC
List price premium$_1$	10.15***		
	(0.0404)		
List price premium$_2$		1.541***	1.541***
		(0.0177)	(0.0177)
ASC within 0 – 1,000 meters			0.0507*
			(0.0263)
ASC within 1,000 – 2,000 meters			0.0379**
			(0.0164)
Monument (1 = Yes)	-0.00446	0.0134	0.0136
	(0.0279)	(0.0334)	(0.0334)
Unique (1 = Yes)	0.00169	0.00324	0.00323
	(0.00210)	(0.00251)	(0.00251)
Luxurious (1 = Yes)	0.0902***	-0.0153	-0.0152
	(0.0123)	(0.0148)	(0.0148)
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	3.597***	3.192***	3.192***
	(0.0344)	(0.0411)	(0.0411)
Observations	121,242	121,242	121,242
Adjusted R-squared	0.450	0.211	0.211
Joint sig. F test	133.1	44.35	44.24
RMSE	0.974	1.166	1.166

Note: The dependent variable is log of time on the market. The reference category is a transaction that occurred in Q4 2016, located in Amsterdam, with a hypothetical nearest ASC distance farther than 2,000 meters. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

6. CONCLUSION

This study explored the economic effect of ASCs on local housing markets. Specifically, it concerned the joint effect of ASCs on sale price and time on the market for houses in the Netherlands. This relation is deemed relevant for two reasons. First, it provides empirical evidence on the economic effects of ASCs. The empirical findings can be used by policy makers that are concerned with the allocation of ASCs, which are often contested based on economic arguments. The second reason for the relevance of this study, is that it expands the relatively small amount of literature that addresses the relation between sale price and time on the market in the light of externalities.

The study of the joint effect of ASCs on sale prices and time on the market is characterized by the endogenous relation between sale price and time on the market. Econometrically, this relation was addressed with a 2SLS model. The 2SLS model was applied to a dataset, provided by COA and NVM, of 544,788 housing transactions that occurred between 1992 and 2016. The results show that consideration of sale prices and time on the market in the same framework is appropriate in the context of studies on externalities. Sale prices were shown to positively affect time on the market, if sale price is considered as determinant of the list price premium. An increase of 1% in the list price premium causes an increase of 1.16% in the time on the market. This effect is in the same direction, but much stronger compared to the effects found in similar studies. Furthermore, time on the market is shown to negatively affect sale prices. A longer time on the market of 1% causes a decrease of 0.056% in sale prices. This finding is in line with some studies, but it contradicts other studies on this topic.

Furthermore, the results show that ASCs have a strongly negative effect on sale prices. Houses that are transacted within 1,000 meters of an ASC have an average lower sale price of 10.3% compared to similar houses that are not transacted near an active ASC. Conversely, the effect on time on the market is strongly positive. Houses that are transacted within 1,000 meters of an ASC have an average time on the market of 21.5% higher than similar houses that were not transacted near an active ASC. Both effects diminish over space. The negative effect of ASCs on sale prices diminishes to 4.8% at more than 2,000 meters distance. The positive effect of ASCs on time on the market diminishes to 4.9% at more than 2,000 meters distance. The robustness of the results was addressed with two methods. First, the variability of the results was tested, by specifying different indicators for the presence of ASCs. The effect of ASCs on sale prices and time on the market remained consistent for different specifications of the categories indicating ranges to the nearest ASC. However, when the presence of an ASC was indicated by a linear and quadratic distance variable, coefficients were found that contradicted the initial results.

Second, the causal effect of ASCs was tested, because it is plausible that ASCs are placed in locations that are characterized by lower sale prices and higher time on the market. The causal effect was tested via falsification, by estimating the effects of ASCs on a subsample that could not have been affected by ASCs. The results show that the negative sale price effect is indeed caused by ASCs. It is unlikely that the negative effects that are found on sale prices are caused by a different, unknown variable. The results of the time on the market estimation are not conclusive. Weak positive effects are found in the robustness tests, indicating that ASCs are placed in locations that are characterized by slightly a higher time on the market. The results therefore suggest an association between ASCs and time on the market. It cannot be definitely concluded that ASCs have a positive causal effect on ASCs.

The findings are in line with the literature. Studies on similar topics show that the presence of a negative externalities is associated with lower sale price and increase time on the market, and this effect is strongest in the closest proximity of the amenity. This study is the first to find such relations in the context of ASCs.

However, as with any study, there are limitations to this research. First, data availability limited the amount of information on ASCs. Because COA does not maintain data on ASCs that are inactive, most ASCs within the dataset opened since 2012. Therefore, most transactions that were relevant for this study took place after 2012. It is possible that this period is characterized by particularly negative opinions of ASCs. To address this possibility, future research on this subject may test if the effects of ASCs are consistent over multiple time periods.

Second, the used method could be improved by including a more refined indicator for the presence of ASCs, instead of Euclidian distance. For example, it seems plausible that the effect of an ASC is related to the capacity of the ASC or the closing date of the ASC. Also, it may be useful to consider the context of the ASC in the analysis. For example, it is possible that the gradient of an ASC's effect is related to the population size or density of its surroundings. By including a more refined indicator for the presence of ASCs, the inconsistent results for range categories and linear and quadratic distance can be better addressed.

Third, the results in this study may be affected by spatial autocorrelation. That is to say, transactions are affected by other transactions that took place recently or nearby. In this context, spatial autocorrelation is best addressed by the spatiotemporal matrix W of Dubé and Legros (2016). The matrix is constructed by using past transactions to estimate sale prices and time on the market. The past transactions are weighted by their proximity in a spatial and temporal dimension with respect to other transactions. The resulting matrix W can be implemented in a 2SLS-framework, which simultaneously addresses spatial autocorrelation and endogeneity. This method is therefore a more elegant approach to the statistical issues related to joint estimation.

Finally, even though the 2SLS method by Knight (2002) is a valid method, other approaches are worth considering in the context of externalities, sale prices, and time on the market. First, the already described method by Dubé and Legros (2016) provides a more refined method to address spatial autocorrelation and endogeneity. Second, the joint log likelihood function of Horowitz (1992) and Huang and Palmquist (2001) provide an opportunity to estimate sale prices and time on the market simultaneously, within one equation. This method can be preferred over 2SLS, because 2SLS finally estimates sale price and time on the market separately. It is therefore worthwhile to replicate this study using these methods, to see if the results remain robust.

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APPENDICES

Appendix A. Gauss-Markov assumptions

	Assumption	Formal statement
1	The errors have zero mean	$E(\varepsilon_t) = 0$
2	The variance of the errors is constant and finite over all values of x_t	$Var(\varepsilon_t) = \sigma^2 < \infty$
3	The errors are statistically independent of one another	$Cov(\varepsilon_i, \varepsilon_j) = 0$ for $i \neq j$
4	There is no relationship between the error and corresponding x variable	$Cov(X,\varepsilon) = 0\ \forall\ X$
5	Disturbances are normally distributed	$\varepsilon_t \sim N(0, \sigma^2)$

Appendix B. List of municipalities

Municipality	Number of observations	Percentage	Municipality	Number of observations	Percentage
Alkmaar	21,550	3.96	Katwijk	7,547	1.39
Almere	34,915	6.41	Maastricht	5,385	0.99
Amsterdam	116,293	21.35	Oisterwijk	3,726	0.68
Apeldoorn	28,906	5.31	Pekela	1,363	0.25
Assen	14,025	2.57	Rheden	7,057	1.30
Borne	3,034	0.56	Rijswijk	8,138	1.49
Boxmeer	2,29	0.42	Rotterdam	60,452	11.10
Coevorden	5,297	0.97	Smallingerland	9,794	1.80
Cranendonck	1,071	0.20	Stadskanaal	2,423	0.44
Delfzijl	3,357	0.62	Tytsjerksteradiel	4,161	0.76
Den Helder	5,304	0.97	Utrecht	61,845	11.35
Deventer	18,371	3.37	Venlo	3,818	0.70
Eindhoven	32,164	5.90	Vlagtwedde	1,259	0.23
Enschede	20,71	3.80	Wageningen	5,278	0.97
Hardenberg	7,409	1.36	Weert	5,395	0.99
Harderwijk	7,875	1.45	Winterswijk	3,193	0.59
Haren	4,776	0.88	Zutphen	8,249	1.51
Heerhugowaard	9,549	1.75			
Hoogeveen	8,809	1.62	Total	544,788	100.00

Appendix C. Data preparation process

This section describes the data trimming process as reported in a Stata do-file. It is based on a relabeled version of the original NVM dataset. The starting number of observations is 796,077. The trimmed dataset contains 544,788 observations.

Description	Code	Number of dropped observations
Merge datasets		
Merge locations to NVM dataset*	merge m:1 PC6 using "D:\Thesis\Data\NVM locations to merge.dta", keepusing(postcode rd_x rd_y latitude longitude)	
Merge COA dataset to NVM dataset*	merge m:1 munname using "D:\Thesis\Data\COA including locations to merge.dta", keepusing(opvangvorm tcap lcap open sluit RD_X RD_Y LAT LON) nogenerate	
Generate usable variables		
Transform sale price to log	gen logsprice = log(sprice)	
Transform list price to log	gen loglprice = log(olistprice)	
Generate list price premium in log	gen loglpricepremium = loglprice/logsprice	
Generate list price premium	gen lpricepremium = olistprice/sprice	
Transform TOM to log	gen logtom = log(tom)	
Transform corrected house area to log	gen logarea = log(area)	
Generate temporary maintenance variable	gen maintenancetemp1 = (maintin+maintout)/2	
Generate good maintenance dummy	gen maintenance = maintenancetemp >7	
Drop temporary maintenance variable	drop maintenancetemp1	
Generate bathroom dummy	gen bathroomdummy = bathroom >=1	
Generate balcony dummy	gen balconydummy = balcony >=1	
Generate garage dummy	gen garagedummy = garage >=1	
Generate terrace dummy	gen terracedummy = terrace>=1	
Generate heating dummy	gen centralheatingdummy = heating>=1	
Generate luxurious dummy	gen luxurious = quality==2	
Generate time restriction	gen timecheck = enddate>open	
Test value	gen testvalue = 1000	
Generate check for time restriction	gen timechecktemp = enddate-open	
Generate robustness time restriction	gen timecheck2 = timechecktemp>testvalue	

Appendix C. Data trimming process (continued)

Description	Code	Number of dropped observations
Generate quarterly dummy**	recode enddate 0/11779 = 1 11780/11870 = 2 … 20729/20820 = 100, generate(quarterdummy)	
Generate house type indicator	recode housetype 1=1 2=0 3=1 4=1 5=0 6=1 7=0 8=1 9=0 10=1 11=1 12=1 13=0 14=0 15=0 16=0 17=0 18=0 19=1 20=1, generate(unique)	
Generate temporary distance to nearest ASC variable	gen ascdistancetemp = sqrt((LAT-latitude)^2 + (LON-longitude)^2)	
Convert ASC distance variable to meters	gen ascdistance = ascdistancetemp*100000	
Generate quadratic ASC distance variable	gen ascdistancesquared = (ascdistance)^2	
Drop temporary distance to nearest ASC variable	drop ascdistancetemp	
Generate control group dummy	gen control = ascdistance>2000	
Generate ASC range dummies for non-treatment group	recode ascdistance 0/1000=1 1000/2000=2 2000/max=3 2500, gen(ascrobust)	
Generate interaction between time restriction and distance to nearest ASC	gen interaction = ascdistance*timecheck	
Generate ASC range dummies (1)	recode interaction 0=0 1/1000 = 1 1000/2000 = 2 2000/max = 3, gen(asccat1)	
Generate ASC range dummies (2)	recode interaction 0=0 1/750 = 1 750/1500 = 2 1500/3000 = 3 3000/max = 4, gen(asccat2)	
Generate ASC range dummies (3)	recode interaction 0=0 1/500 = 1 500/2000 = 2 2000/max = 3, gen(asccat)	
Generate ZIP-code dummies	qui tab postcode, gen(pc)	
Drop missing house type	drop if housetype ==-1 | housetype ==0	4,261
Generate house type dummies	qui tab housetype, gen(htype)	
Drop missing build period	Drop if buildp ==-1| buildp ==0	8,107
Generate building period dummies	qui tab buildp, gen(bperiod)	

Appendix C. Data trimming process (continued)

Description	Code	Number of dropped observations
Drop cases with missing or implausible values		
Drop implausible sale prices***	drop if sprice <=25000 | sprice >=2000000	2,956
Drop implausible starting list prices***	drop if olistprice <=25000 | olistprice >=2000000	1,921
Drop implausible list price/sale price ratio's	drop if lpricepremium <.5 | lpricepremium >1.5	3,777
Drop implausible time on the market	drop if tom <=1 | tom >2000	20,606
Drop implausible area	drop if area <= 25 | area >=250	47,550
Drop if bathroom is missing	drop if bathroomdummy ==0	85,327
Drop if house type does not constitute a regular home (i.e. Caravan, Modest, Houseboat, Recreational)	drop if housetype ==1 | housetype ==2 | housetype==3 | housetype==4	16,528
Drop implausible or missing ASC distances	drop if ascdistance >=50000	60,256

Notes:
* Locations of NVM transactions and COA ASCs were geocoded via an Oracle script provided by Ortec Finance. The script is not made available for this appendix.
** Quarterly dummies are based on the date of sale. Date of sale is reported as number of days since January 1st, 1960.
*** Sale price and list price in the dataset represent nominal values. 25,000 euro in 1992 roughly corresponds to 50,000 euro in 2017.

Appendix D. Frequency tables

Appendix D.1. Frequency table for observations in specific ASC ranges (1)

Distance to ASC in meters	Frequency	Percentage	Cum. Percentage
No treatment	491,947	90.30	90.30
0 – 1,000	2,417	0.44	90.74
1,000 – 2,000	7,210	1.32	92.07
> 2,000	43,214	7.93	100.00
Total	544,788	100.00	

Appendix D.2. Frequency table for observations in specific ASC ranges (2)

Distance to ASC in meters	Frequency	Percentage	Cum. Percentage
No treatment	491,947	90.30	90.30
0 – 750	1,198	0.22	90.52
750 – 1,500	4,279	0.79	91.31
1,500 – 3,000	13,686	2.51	93.82
> 3,000	33,678	6.18	100.00
Total	544,788	100.00	

Appendix D.3. Frequency table for observations in specific ASC ranges (3)

Distance to ASC in meters	Frequency	Percentage	Cum. Percentage
No treatment	491,947	90.30	90.30
0 – 500	350	0.06	90.36
500 – 2,000	9,277	1.70	92.07
> 2,000	43,214	7.93	100.00
Total	544,788	100.00	

Appendix E. Full estimation results

Appendix E. Full 2SLS sale price estimates (table 5)

	Model 1	Model 2	Model 3
Variables	Restricted model	Partial second stage	Second stage + ASC
TOM_1		-0.0559***	-0.0556***
		(0.000409)	(0.000409)
ASC within 0 – 1,000 meters			-0.103***
			(0.00423)
ASC within 1,000 – 2,000 meters			-0.0696***
			(0.00264)
ASC farther than 2,000 meters			-0.0476***
			(0.00158)
Area	0.744***	0.753***	0.753***
	(0.00107)	(0.00106)	(0.00106)
Maintenance [1 = Good]	0.0802***	0.0786***	0.0787***
	(0.000676)	(0.000664)	(0.000663)
Monument (1 = Yes)	0.0926***	0.0918***	0.0913***
	(0.00253)	(0.00249)	(0.00249)
Balcony (1 = Yes)	0.0216***	0.0201***	0.0200***
	(0.000686)	(0.000675)	(0.000674)
Garage (1 = Yes)	0.132***	0.137***	0.137***
	(0.000779)	(0.000767)	(0.000766)
Terrace (1 = Yes)	0.0526***	0.0528***	0.0528***
	(0.000997)	(0.000980)	(0.000979)
Central heating (1 = Yes)	0.0340***	0.0339***	0.0335***
	(0.00156)	(0.00153)	(0.00153)
Building period: 1500 - 1905	-0.0892***	-0.0851***	-0.0848***
	(0.00179)	(0.00176)	(0.00176)
Building period: 1906 - 1930	-0.131***	-0.127***	-0.127***
	(0.00157)	(0.00154)	(0.00154)
Building period: 1931 - 1944	-0.127***	-0.125***	-0.124***
	(0.00165)	(0.00163)	(0.00162)
Building period: 1945 - 1959	-0.183***	-0.181***	-0.181***
	(0.00169)	(0.00166)	(0.00166)
Building period: 1960 - 1970	-0.228***	-0.229***	-0.229***
	(0.00155)	(0.00153)	(0.00153)
Building period: 1971 - 1980	-0.190***	-0.193***	-0.194***
	(0.00157)	(0.00154)	(0.00154)
Building period: 1981 - 1990	-0.128***	-0.133***	-0.133***
	(0.00153)	(0.00151)	(0.00150)
Building period: 1991 - 2000	-0.0409***	-0.0426***	-0.0426***

	(0.00142)	(0.00139)	(0.00139)
House type: Canal house	0.121***	0.128***	0.128***
	(0.00697)	(0.00686)	(0.00685)
House type: Mansion	0.122***	0.124***	0.124***
	(0.00108)	(0.00106)	(0.00106)
House type: Farm	0.320***	0.328***	0.328***
	(0.00423)	(0.00416)	(0.00415)
House type: Bungalow	0.275***	0.286***	0.286***
	(0.00188)	(0.00185)	(0.00185)
House type: Villa	0.351***	0.363***	0.363***
	(0.00224)	(0.00220)	(0.00220)
House type: Countryhouse	0.392***	0.401***	0.401***
	(0.00424)	(0.00417)	(0.00416)
House type: Estate	0.459***	0.465***	0.467***
	(0.0609)	(0.0599)	(0.0598)
House type: Downstairs house	-0.00177	0.000131	-2.32e-05
	(0.00135)	(0.00132)	(0.00132)
House type: Upstairs house	-0.0696***	-0.0672***	-0.0677***
	(0.00120)	(0.00118)	(0.00118)
House type: Maisonette	-0.109***	-0.106***	-0.105***
	(0.00163)	(0.00160)	(0.00160)
House type: Flat	-0.0711***	-0.0662***	-0.0655***
	(0.00115)	(0.00114)	(0.00113)
House type: Apartment	-0.0922***	-0.0860***	-0.0853***
	(0.00126)	(0.00124)	(0.00124)
House type: Hospice	-0.431***	-0.412***	-0.410***
	(0.00645)	(0.00634)	(0.00634)
House type: Down- and upstairs house	0.0203***	0.0259***	0.0261***
	(0.00400)	(0.00393)	(0.00393)
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	9.463***	9.615***	9.663***
	(0.00659)	(0.00658)	(0.00671)
Observations	544,788	544,788	544,788
Adjusted R-squared	0.873	0.877	0.877
Joint sig. F test	4743	4923	4919
RMSE	0.182	0.179	0.179

Note: The dependent variable is log of sale price. The reference category is a single-family house that was built after 2001, transacted in Q4 2016, located in Amsterdam, with no ASC treatment. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

Appendix F. Full robustness estimation results

Appendix F.1. Full results robustness analysis on sale price (table 7)

	Model 7	Model 8	Model 9
Variables	Second stage sale price with ASC categories: 0 – 750 750 – 1,500 1,500 – 3000 3,000 – max	Second stage sale price with ASC categories: 0 – 500 500 – 2,000 3,000 – max	Second stage sale price with linear and quadratic ASC distances
TOM_1	-0.0556***	-0.0556***	-0.0559***
	(0.000409)	(0.000409)	(0.000409)
ASC within 0 – 750 meters	-0.0904***		
	(0.00561)		
ASC within 750 – 1,500 meters	-0.0903***		
	(0.00327)		
ASC within 1,500 – 3,000 meters	-0.0574***		
	(0.00211)		
ASC farther than 3,000 meters	-0.0447***		
	(0.00171)		
ASC within 0 – 500 meters		-0.0948***	
		(0.00991)	
ASC within 500 – 2,000 meters		-0.0761***	
		(0.00249)	
ASC farther than 2,000 meters		-0.0477***	
		(0.00158)	
ASC linear distance			-8.87e-06***
			(6.61e-07)
ASC quadratic distance			2.45e-10***
			(0)
Area	0.753***	0.753***	0.753***
	(0.00106)	(0.00106)	(0.00106)
Maintenance [1 = Good]	0.0787***	0.0787***	0.0786***
	(0.000663)	(0.000664)	(0.000664)
Monument (1 = Yes)	0.0914***	0.0913***	0.0916***
	(0.00249)	(0.00249)	(0.00249)
Balcony (1 = Yes)	0.0200***	0.0200***	0.0201***
	(0.000674)	(0.000674)	(0.000675)
Garage (1 = Yes)	0.137***	0.137***	0.137***
	(0.000766)	(0.000766)	(0.000767)
Terrace (1 = Yes)	0.0527***	0.0528***	0.0528***
	(0.000979)	(0.000979)	(0.000980)
Central heating (1 = Yes)	0.0335***	0.0335***	0.0339***
	(0.00153)	(0.00153)	(0.00153)
Building period: 1500 - 1905	-0.0848***	-0.0848***	-0.0859***
	(0.00176)	(0.00176)	(0.00176)
Building period: 1906 - 1930	-0.127***	-0.127***	-0.128***
	(0.00154)	(0.00154)	(0.00154)
Building period: 1931 - 1944	-0.124***	-0.124***	-0.126***
	(0.00162)	(0.00162)	(0.00163)
Building period: 1945 - 1959	-0.181***	-0.181***	-0.182***

	(0.00166)	(0.00166)	(0.00166)
Building period: 1960 - 1970	-0.229***	-0.229***	-0.230***
	(0.00153)	(0.00153)	(0.00153)
Building period: 1971 - 1980	-0.194***	-0.193***	-0.194***
	(0.00154)	(0.00154)	(0.00154)
Building period: 1981 - 1990	-0.133***	-0.133***	-0.133***
	(0.00150)	(0.00150)	(0.00151)
Building period: 1991 - 2000	-0.0426***	-0.0425***	-0.0430***
	(0.00139)	(0.00139)	(0.00139)
House type: Canal house	0.128***	0.128***	0.129***
	(0.00685)	(0.00685)	(0.00685)
House type: Mansion	0.124***	0.124***	0.124***
	(0.00106)	(0.00106)	(0.00106)
House type: Farm	0.328***	0.328***	0.328***
	(0.00415)	(0.00415)	(0.00416)
House type: Bungalow	0.286***	0.286***	0.286***
	(0.00185)	(0.00185)	(0.00185)
House type: Villa	0.363***	0.363***	0.363***
	(0.00220)	(0.00220)	(0.00220)
House type: Country house	0.401***	0.401***	0.401***
	(0.00416)	(0.00416)	(0.00417)
House type: Estate	0.466***	0.467***	0.469***
	(0.0598)	(0.0598)	(0.0599)
House type: Downstairs house	4.00e-07	1.74e-05	-2.38e-05
	(0.00132)	(0.00132)	(0.00132)
House type: Upstairs house	-0.0677***	-0.0676***	-0.0674***
	(0.00118)	(0.00118)	(0.00118)
House type: Maisonette	-0.105***	-0.105***	-0.106***
	(0.00160)	(0.00160)	(0.00160)
House type: Flat	-0.0655***	-0.0655***	-0.0664***
	(0.00113)	(0.00113)	(0.00114)
House type: Apartment	-0.0851***	-0.0852***	-0.0862***
	(0.00124)	(0.00124)	(0.00124)
House type: Hospice	-0.410***	-0.409***	-0.414***
	(0.00634)	(0.00634)	(0.00634)
House type: Down- and upstairs house	0.0261***	0.0260***	0.0257***
	(0.00392)	(0.00393)	(0.00393)
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	9.662***	9.662***	9.671***
	(0.00671)	(0.00671)	(0.00773)
Observations	544,788	544,788	544,788
Adjusted R-squared	0.877	0.877	0.877
Joint sig. F test	4913	4919	4913
RMSE	0.179	0.179	0.179

Note: The dependent variable is log of sale price. The reference category is a single-family house that was built after 2001, transacted in Q4 2016, located in Amsterdam, with no ASC treatment. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

Appendix F.2. Full results robustness analysis time on the market (table 8)

Variables	Model 10 Second stage sale price with ASC categories: 0 – 750 750 – 1,500 1,500 – 3000 3,000 – max	Model 11 Second stage sale price with ASC categories: 0 – 500 500 – 2,000 3,000 – max	Model 12 Second stage sale price with linear and quadratic ASC distances
List price premium2	1.161***	1.161***	1.158***
	(0.00786)	(0.00786)	(0.00786)
ASC within 0 – 750 meters	0.261***		
	(0.0340)		
ASC within 750 – 1,500 meters	0.141***		
	(0.0198)		
ASC within 1,500 – 3,000 meters	0.108***		
	(0.0128)		
ASC farther than 3,000 meters	0.0382***		
	(0.0104)		
ASC within 0 – 500 meters		0.296***	
		(0.0601)	
ASC within 500 – 2,000 meters		0.164***	
		(0.0151)	
ASC farther than 2,000 meters		0.0491***	
		(0.00959)	
ASC linear distance			2.27e-05***
			(4.00e-06)
ASC quadratic distance			-1.77e-10
			(1.77e-10)
Monument (1 = Yes)	0.0415***	0.0417***	0.0419***
	(0.0149)	(0.0149)	(0.0149)
Unique (1 = Yes)	0.00732***	0.00736***	0.00744***
	(0.00115)	(0.00115)	(0.00115)
Luxurious (1 = Yes)	-0.00118	-0.00111	-0.000298
	(0.00627)	(0.00627)	(0.00627)
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	3.446***	3.444***	3.338***
	(0.0226)	(0.0226)	(0.0319)
Observations	544,788	544,788	544,788
Adjusted R-squared	0.183	0.183	0.183
Joint sig. F test	159.8	160	160.1
RMSE	1.086	1.086	1.086

Note: The dependent variable is log of time on the market. The reference category is a transaction that occurred in Q4 2016, located in Amsterdam, with no ASC treatment. All models include structural variables, fixed effects and list price premium2, equal to Model 6. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.

Appendix F.3. Full 2SLS sale price estimates on non-treatment observations (table 9)

	Model 1	Model 2	Model 3
Variables	Restricted model	Partial second stage	Second stage + ASC
TOM_1		-0.0444***	-0.0444***
		(0.000737)	(0.000737)
ASC within 0 – 1,000 meters			-0.00519
			(0.00403)
ASC within 1,000 – 2,000 meters			-0.00227
			(0.00252)
Area	0.785***	0.790***	0.790***
	(0.00222)	(0.00219)	(0.00219)
Maintenance [1 = Good]	0.0902***	0.0884***	0.0884***
	(0.00151)	(0.00149)	(0.00149)
Monument (1 = Yes)	0.0657***	0.0644***	0.0644***
	(0.00526)	(0.00518)	(0.00518)
Balcony (1 = Yes)	0.0252***	0.0243***	0.0243***
	(0.00153)	(0.00151)	(0.00151)
Garage (1 = Yes)	0.129***	0.134***	0.134***
	(0.00156)	(0.00154)	(0.00154)
Terrace (1 = Yes)	0.0437***	0.0454***	0.0454***
	(0.00197)	(0.00195)	(0.00195)
Central heating (1 = Yes)	0.0206***	0.0216***	0.0216***
	(0.00361)	(0.00356)	(0.00356)
Building period: 1500 - 1905	-0.0415***	-0.0385***	-0.0385***
	(0.00346)	(0.00341)	(0.00341)
Building period: 1906 - 1930	-0.0894***	-0.0870***	-0.0869***
	(0.00281)	(0.00277)	(0.00277)
Building period: 1931 - 1944	-0.0807***	-0.0798***	-0.0798***
	(0.00311)	(0.00307)	(0.00307)
Building period: 1945 - 1959	-0.180***	-0.180***	-0.180***
	(0.00311)	(0.00306)	(0.00306)
Building period: 1960 - 1970	-0.248***	-0.248***	-0.248***
	(0.00272)	(0.00268)	(0.00268)
Building period: 1971 - 1980	-0.220***	-0.222***	-0.222***
	(0.00272)	(0.00268)	(0.00268)
Building period: 1981 - 1990	-0.142***	-0.145***	-0.145***
	(0.00266)	(0.00262)	(0.00262)
Building period: 1991 - 2000	-0.0488***	-0.0499***	-0.0499***
	(0.00241)	(0.00237)	(0.00237)
House type: Canal house	0.152***	0.160***	0.160***
	(0.0171)	(0.0168)	(0.0168)
House type: Mansion	0.0954***	0.100***	0.100***
	(0.00264)	(0.00261)	(0.00261)
House type: Farm	0.242***	0.250***	0.250***
	(0.00674)	(0.00665)	(0.00665)
House type: Bungalow	0.217***	0.228***	0.228***
	(0.00349)	(0.00345)	(0.00345)
House type: Villa	0.303***	0.320***	0.320***
	(0.00463)	(0.00457)	(0.00457)
House type: Countryhouse	0.339***	0.349***	0.349***

	(0.00833)	(0.00821)	(0.00821)
House type: Estate	0.341***	0.336***	0.336***
	(0.105)	(0.104)	(0.104)
House type: Downstairs house	-0.0479***	-0.0416***	-0.0416***
	(0.00288)	(0.00284)	(0.00284)
House type: Upstairs house	-0.105***	-0.0977***	-0.0977***
	(0.00266)	(0.00263)	(0.00263)
House type: Maisonette	-0.143***	-0.138***	-0.138***
	(0.00362)	(0.00357)	(0.00357)
House type: Flat	-0.0770***	-0.0707***	-0.0707***
	(0.00245)	(0.00242)	(0.00242)
House type: Apartment	-0.104***	-0.0969***	-0.0970***
	(0.00291)	(0.00287)	(0.00287)
House type: Hospice	-0.342***	-0.330***	-0.330***
	(0.0149)	(0.0147)	(0.0147)
House type: Down- and upstairs house	0.0360***	0.0383***	0.0383***
	(0.00812)	(0.00800)	(0.00800)
Time fixed effects	*Yes*	*Yes*	*Yes*
ZIP-code fixed effects	*Yes*	*Yes*	*Yes*
Constant	9.464***	9.570***	9.570***
	(0.0132)	(0.0131)	(0.0131)
Observations	121,242	121,242	121,242
Adjusted R-squared	0.865	0.869	0.869
Joint sig. F test	1000	1034	1031
RMSE	0.181	0.179	0.179

Note: The dependent variable is log of sale price. The reference category is a single-family house that was built after 2001, transacted in Q4 2016, located in Amsterdam, with a hypothetical nearest ASC distance farther than 2,000 meters. Standard errors in parentheses with ***, **, * indicating significance at 1%, 5% and 10%, respectively.