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Asymmetric information and list-price reductions in the housing market☆

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ABSTRACT

In housing markets with asymmetric information list prices may signal unobserved properties of the house or the seller. Asymmetric information is the starting point for many models for the housing market. In this paper, we estimate the causal effect of list-price reductions on the time houses remain for sale on the market to test for the presence of asymmetric information. We use very rich and extensive administrative data from the Netherlands. Our empirical results show that list-price reductions significantly increase the selling rate of a house, but also the rate of withdrawal from the market increases.

1. Introduction

Heterogeneity in the housing market is often considered to be quite substantial. Houses, for example, differ in size, location and quality. Many of such house characteristics are revealed to potential buyers when a house is put up for sale on the market. In fact, real-estate brokers often add an extensive list of house characteristics including pictures to their advertisements of houses for sale. However, there may remain characteristics, which are known to the seller, but unobserved by potential buyers. These may not only be characteristics of the house, but may also relate to the seller. Sellers can, for example, differ in risk preference, financial constraints and patience. In theoretical models for the housing market such asymmetric information is often ignored. Some exceptions are Albrecht et al. (2012) and Taylor (1999). An important question is to which extent information asymmetries are important in the housing market.

In this paper, we focus on how changes in the list price affect the time a house remains on the market. List prices are not binding in the Dutch housing market. They have no formal role, and by law sellers have to provide all relevant information about the house. The lack of any legal commitment implies that if the market is characterized by symmetric information between buyers and sellers, the list price does not have any effect on outcomes. However, in case of asymmetric information, the list price can signal some unobserved properties of the house or the seller (e.g. Albrecht et al., 2012). More patient sellers may, for example, set a higher list price than desperate sellers. Indeed, Genesove and Mayer (1997) show that sellers with a higher loan-to-value set a higher list price and experience a longer time to sale. Genesove and Mayer (2001) attribute this to loss aversion of sellers. Based on this finding, they conclude that the real-estate market is not a perfect asset market. We sketch the setup of a theoretical housing model with asymmetric information. This model guides interpretation for our empirical analysis.

Estimating the causal effect of the list price on outcomes in the housing market is complicated. There may be characteristics which are observed by both buyers and sellers, but which are unobserved by the econometrician. For example, the thinness of the market for a particular house affects both the list price and the probability of selling the house (e.g. Lazear, 1986). Therefore, we focus on the effects of changes in list prices while a house is on the market, rather than the initial level of the list price. However, Lazear (1986) shows that also changes in the

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list price are not exogenous; market thinness may affect list-price changes. This is confirmed by Sass (1988), who shows that the size of the pool of potential buyers is important. Deng et al. (2009) show that less-informed sellers set a higher list price, are more likely to reduce the list price and sell at a lower price.

We use a timing-of-events duration model to estimate the causal effect of a list-price change on the time a house is on the market. The empirical model extends the competing risks model used by, for example, Deng et al. (2000, 2005). Abbring and Van den Berg (2003a) show that identification of the causal effect of a list-price change depends upon buyers not anticipating the exact moment at which the list prices is reduced. No anticipation only implies that buyers do not know the exact moment at which the list price is lowered, i.e. the actual list-price reduction causes a shock. Buyers may, however, know that certain houses are at risk of lowering the list price or that list prices are likely to be lowered in certain time periods. No anticipation thus does not imply that list-price reductions are exogenous, or that the rate at which list prices are reduced is the same over time. Houses may have different rates at which list prices are reduced, and it may be that during particular periods a list-price reduction is more likely than in other periods. Therefore, we explicitly allow for selection on unobservables. Also if some houses never lower the list price (i.e., the duration distribution until lowering the list price is defective), the model is still identified. We not only focus on the time until selling the house, but also allow for the option to withdraw a house from the market. Withdrawing a house from the market is not exogenous (e.g. Taylor, 1999). We explicitly incorporate this in our model by having competing risks.

We use a unique administrative data set provided by the Dutch NVM (Association of Real Estate Brokers and Real Estate Experts) on houses put for sale on the Dutch housing market during the period 2005–2007. The data contain daily information on the time the house was on the market. Also the reason for leaving the market is recorded, so we also observe houses withdrawn from the market by the seller. Such information is not trivial. Caplin and Leahy (1996) discuss the consequences of self selection in markets with frictions such as real-estate markets, when only sales are observed. Withdrawal data contain important information about the selling process (e.g. Taylor, 1999). Our data contain not only the initial list price, but are also informative on the dates and magnitudes of all list-price changes. Furthermore, we observe a very extensive set of characteristics of each house.

Our paper contributes to two earlier studies considering list-price changes. Both Knight (2002) and Merlo and Ortalo-Magné (2004) provide descriptive evidence on list-price reductions. Knight (2002) suggests that high initial list prices are costly to the seller. Those houses with large reductions in initial list prices take longer to sell and ultimately sell at lower prices. Merlo and Ortalo-Magné (2004) establish a number of stylized facts of bidding behavior and list-price changes.

The remainder of the paper is organized as follows. Section 2 describes the institutional setting of the Dutch market for owner-occupied houses. Section 3 describes our empirical model that is inspired by some theoretical literature. Section 4 describes the unique administrative data set. Section 5 presents the estimation results and some sensitivity analyses. Section 6 concludes.

2. Owner occupied housing market in the Netherlands

In this section, we describe some institutions of the Dutch housing market. We focus on the owner-occupied sector, and highlight aspects relevant for our purposes. According to Statistics Netherlands in 2006, 56% of the seven million households in the Netherlands were living in an owner-occupied house. The average price of owner-occupied houses was €235,842, which is 4.57 times the average household income.

During the 1990s the Dutch housing market experienced a large real-price increase. Apart from a growth in real income, this price increase is often explained from population growth, stringent spatial-planning policies reducing the construction of new houses, reduced interest rates on mortgages, and changes in the Dutch mortgage-finance market.[1] Usually banks restrict mortgages to 4.5 times the household income, but in exceptional cases they give higher mortgages. There is no restriction on the loan-to-value ratio. Ball (2009) indicates that in 2007 the loan-to-value ratio of first-time buyers was 114%.

There are substantial transaction costs associated with purchasing a house. For existing houses there is a transaction tax of 6%, which is absent for new houses. Broker costs are between 1% and 3% of the selling price, and mortgages often have a 1% to 1.5% initiation fee. Furthermore, there are notary fees and possible intermediary fees. Total transaction costs are approximately 10% of the selling price, and are often financed by including them in the mortgage principle.

Usually when selling a house, the seller approaches a real-estate broker. Most real-estate brokers are connected to the NVM. Actually, about 70% of all houses offered for sale are offered through a member of the NVM. The broker advises the seller on an appropriate list price, but the seller determines the list price. The real-estate broker adds the house to a publicly available website with a list price, a detailed description on the characteristics and some pictures. This website also contains information about socioeconomic characteristics of the neighborhood. The seller can choose to advertise in media such as local newspapers. An interested potential buyer contacts the broker for information on the house or to visit the house. A visit to the house is usually hosted by the broker, and the seller will not be present.

In the Netherlands, list prices do not have a formal role as they are not binding. So even if a buyer is willing to pay the list price, a seller can refuse or try to negotiate a higher price. There are rules for negotiating with potential buyers. Potential buyers communicate their bids to the broker. The broker will then contact the seller and this starts the negotiation process. Sellers are not allowed to negotiate with multiple buyers at the same time or to reveal bids to other buyers. Furthermore, the seller must negotiate with potential buyers in the order in which they made their first bid. Finally, if after selling the house it turns out that there are defects to the house, the buyer can hold the seller liable for the costs of repairing (even in case the buyer inspected the house during the sale). The seller thus has by law the obligation to reveal all information about the house.

3. The model

3.1. Theoretical framework

An early model for the housing market was developed by Olsen (1969). Because it is a model of perfect competition and symmetric information, list prices play no role. Genesove and Mayer (2001) conclude from the result that transaction prices depend also on seller's characteristics, that real-estate markets differ from perfect asset markets. Below we sketch a theoretical framework in which sellers use list prices to signal private information to buyers. So, the discussion allows for the possibility of asymmetric information.[2] We do not show formal proofs, but indicate at which stage list prices may be important.

[1] Since 1990 mortgages can be based on total household income rather than the income of the highest earner. Furthermore, during the 1990s new mortgage products were introduced which exploited more the existing tax benefits. Interest payments on mortgages are for 30 years 100% deductable.

[2] When considering asymmetric information we implicitly assume that the seller has more information, which may either relate to the seller's type (e.g. patience) or the quality of the house. However, it may also imply that the seller has some private belief about the local housing market. Deng et al. (2009) show that the strategy of sellers depends on how well informed they are.

Assume that at the moment a house is put for sale on the market the seller characterizes the house by observed characteristics x, and private information z. Observed characteristics x are attributes of the house in which potential buyers can observe without actually visiting the house. These are, for example, the size of the house, time period in which the house was built and location. The private information z to the seller may include, for example, the patience of the seller and as suggested by Genesove and Mayer (1997, 2001) the seller's financial constraints and loss aversion. Wheaton (1990) distinguishes whether or not the seller already holds a new house.

When putting a house on the market the seller not only reveals the observed characteristics x, but also decides about the list price p_l. Unlike what is assumed by the pricing model of Lazear (1986) and the housing model of Taylor (1999), a list price is not binding in the Dutch housing market. List prices can, therefore, be used as signals for the seller's private information z. We follow Albrecht et al. (2012) in assuming that search of buyers is directed, so based on the observed characteristics x and the list price p_l they determine to visit a house. Visiting a house is costly to buyers who devote time to inspecting the house. Once having visited the house the buyer receives a matched-specific value for the house. The idea is that the buyer observes her tastes and preferences y for this particular house, which is difficult to observe directly. The match-specific value of a bidder is value $u(x, y)$. The taste y of a buyer can be related to the private information z of the seller, for example, when it related to maintenance or the painting which cannot be observed without a visit. Therefore, we assume that y is a draw from the distribution function $F(y|z)$.

Let $\lambda(x, p_l, v)$ be the rate at which potential buyers visit a house with characteristics x and list price p_l. This rate also depends on local housing-market conditions v, which may include the thinness of the market segment. If y would be independent of v and sellers choose p_l such that it is positively correlated to v, then buyers always prefer houses with a low list price. This would rationalize Haurin et al. (2010), who impose that the rate at which bidders arrive is decreasing in the level of the list price. However, this is not necessarily true if y and z are not independent.

When the match-specific value of the buyer corrected for the expected price, $u(x, y) - \mathrm{E}[p|x, y, p]$, exceeds the continuation value of searching R_b, the buyer makes an offer, which starts the negotiation over the price (e.g., Genesove and Han, 2012). Deng et al. (2009), Horowitz (1992) and Haurin et al. (2010) impose that when bids arrive, sellers have to decide to reject or accept a bid immediately. Negotiations are usually fast in particular relative to the rate at which buyers arrive. In their models, Deng et al. (2009) and Horowitz (1992) impose that the distribution of bids depends on the list price. For sellers the negotiation can only lead to selling the house if the selling price p exceeds the reservation price p_r.

The reservation price is the result of optimization of the seller. So, the reservation price not only depends on the characteristics of the house x and the private information z, but the seller also takes into account the rate at which buyers arrive $\lambda(x, p_l, v)$ and the distribution $F(y|v)$ of buyers' preferences y (e.g. Deng et al., 2009). Albrecht et al. (2012) discuss that in equilibrium sellers are inclined to reveal their type z when setting the list price for their house. The argument is relatively straightforward if we allow buyers to be heterogeneous in the weight they put on y in their match-specific value $u(x, y)$. Sellers who set a relatively low list price attract mainly buyers with a low weight on y and these potential buyers are not willing to pay a high price if y is favorable. On the other hand, houses with a high list price are visited by buyers with a high weight on y and these buyers do not start a price negotiation if the match-specific value $u(x, y)$ turns out to be low. Heterogeneous buyer preferences and directed search thus suggests that sellers use the list price to signal their private information.

It is easy to argue that in the absence of asymmetric information, list prices do not play any role. The case in which all information known to the seller is also observed by potential buyers can be considered as z being included in x. In that case there is no seller's type which can be revealed using the list price. So buyers will ignore it when determining which house to visit and also in the possible negotiation about the selling price the list price plays no role.

The initial list price is likely to be related to existing market conditions v. In a market with many buyers, the rate at which buyers arrive $\lambda(x, p_l, v)$ will be high. Therefore, sellers will have higher reservation prices and selling prices will be higher. This is reflected in higher list prices (if one believes that the scale of the list price is related to the expected selling price). The private information of the seller can change over time. As already mentioned above, the private information can also contain the patience of the seller. When the time for which the house is on the market proceeds, the seller might become more impatient. This may be the results of approaching the date at which the seller is scheduled to move to a new house. Once the seller becomes impatient and is willing to sell the house for a lower price, the seller may want to signal this to potential buyers by lowering the list price. A lower list price should attract a new set of potential buyers, which can increase the selling rate of the house.

So far we assumed that sellers know the market, i.e. they know the rate at which potential buyers arrive $\lambda(x, p_l, v)$ and the distribution of buyers' preferences and tastes $F(y|v)$. Lazear (1986) discusses markets in which sellers face uncertainty. Uncertainty implies that after the house is put on the market sellers learn about the rate at which buyers arrive and their distribution of valuations. While the house is on the market sellers will only reduce their beliefs about buyers' valuations, because before actually selling the house they either meet no buyers or buyers who are not willing to buy the house. This will induce sellers to lower their list price. Lazear (1986) shows that the speed of learning is related to market thinness. In thinner markets sellers receive fewer signals and reduce their list prices less rapidly.[3] Sass (1988) shows that also the size of the potential set of buyers is important. Fewer potential buyers increase the rate at which prices are reduced. Also Deng et al. (2009) relate a high initial list price and a relatively fast reduction of the list price to sellers being less well informed.

Taylor (1999) considers a housing market with two-sided asymmetric information. Buyers can use the elapsed duration for which houses have already been on the market as a signal for the seller's private information z. The idea is that if a house is already on the market for a longer time, it is likely that it has already been visited by many other buyers, but this did not result in actually selling the house. Houses that remain on the market too long get stigmatized. Indeed, empirical evidence confirms that the probability of sales decreases with time on the market (e.g. Anglin et al., 2003; De Wit, 2010; Huang and Palmquist, 2001; Pryce and Gibb, 2006; Zuehlke, 1987).

To avoid stigmatization sellers can reduce their list price. Taylor (1999) argues that this is only effective in attracting new buyers if these can observe list-price histories. If the latter is not the case, the selling process of the house may suffer from buyer herding and information cascades. This will result in sale becoming unlikely and the seller eventually removing the house from the market. This shows that withdrawal from the market is not exogenous to selling the house, and the empirical analysis should take this into account.

The key conclusion from this theoretical discussion is that (if list prices are not binding) in the absence of asymmetric information list prices do not play any role. This implies that the level of the list price and changes in the list price do not affect the probability of sale. It is important to distinguish between information known to the market and to the econometrician. For example, market thinness within particular segments may be known to both buyers and sellers, but is unknown to the econometrician (Lazear, 1986). Furthermore, withdrawing might

[3] A similar argument can be made for demand shocks which are not directly observed by sellers. In our empirical analysis we include quarterly dummies to capture such shocks.

not be exogenous in a housing market of asymmetric information (Taylor, 1999).

3.2. Empirical model

The key empirical problem is that list prices are endogenous. There may be relevant market characteristics that are observed by both the buyer and the seller, which are unobserved by the econometrician. Therefore, we focus on list-price changes rather than the level of the list price. We use the timing-of-events duration model to estimate the causal effect of a list-price change on the rate of selling the house (e.g. Abbring and Van den Berg, 2003a).[4] Furthermore, we jointly model withdrawals from the market, as Taylor (1999) shows that the process of withdrawing a house may not be independent of the process of selling the house in a market of asymmetric information. We incorporate this in the model by having dependent competing risks (e.g. Deng et al., 2000, 2005).

Our data contain houses which became for sale between January 2005 and December 2007. For each house we observe the exact date of entering the market, the date of leaving the market, and the reason for leaving the market (sale or withdrawal). Furthermore, we observe the initial list price, and the date and magnitudes of all list-price changes while the house was on the market. We only focus on the first list-price change. About 20% of the houses entering the market change list price, but only in 0.76% of the cases is the list price changed more than once.

Consider a house which is put on the market at (calendar) date τ_0. Our model is a continuous-time duration model in which t denotes the time a house is already on the market and t_p the duration until changing the list price. Let θ_s denote the rate at which houses are sold, and θ_w the rate at which houses are withdrawn from the market. These transition rates can depend on the duration the house is already on the market t, calendar time $\tau_0 + t$, observed characteristics x, some characteristics v which are observed by the market but unobserved to the econometrician, and a variable indicating whether a list price was lowered $I(t_p < t)$ (with $I(\cdot)$ the indicator function). Lowering a list price has a permanent effect on the rate at which houses are sold and the rate at which houses are withdrawn. We relax this assumption in Subsection 5.2 when we perform a number of sensitivity analyses.

We denote the unobserved term v in the rate of selling the house by v_s, and in the rate of withdrawing by v_w. These terms are allowed to be correlated to each other, but are assumed to be independent of x and τ_0. Since the variables in x are mainly used as control variables, and we will not causally interpret their covariate effect, this is not a strong assumption. Conditional on τ_0, x, v_s and t_p, the rate at which a house is sold after t periods on the market follows a familiar mixed proportional hazard specification

$$\theta_s\left(t \middle| x, \tau_0, v_s, t_p\right) = \lambda_s(t)\psi_s(\tau_0 + t)exp\left(x'\beta_s + \delta_s \cdot I\left(t_p < t\right) + v_s\right)$$

And a similar specification is used for the rate at which houses are withdrawn from the market

$$\theta_w\left(t \middle| x, \tau_0, v_w, t_p\right) = \lambda_w(t)\psi_w(\tau_0 + t)exp\left(x'\beta_w + \delta_w \cdot I\left(t_p < t\right) + v_w\right)$$

In these specification $\psi_s(\tau_0 + t)$ and $\psi_w(\tau_0 + t)$ are genuine calendar-time effects modeled by dummies for each quarter. The functions $\lambda_s(t)$ and $\lambda_w(t)$ represent duration dependence, which might, for example, be the consequence of stigmatization. In a housing market with symmetric information, time on the market does not provide a signal to the market and the duration-dependence term should be constant. The parameter δ_s is the key parameter of interest as this denotes the causal effect of a list-price reduction on the rate at which houses are sold. In case of symmetric information, list prices are irrelevant. Our test for symmetric information consists of testing if δ_s is equal to zero. The parameter δ_w describes the effect of a list-price reduction on the rate of withdrawing the house from the market.

The timing of a list-price reduction t_p is most likely not exogenously determined. Therefore, we jointly model the timing of a list-price reduction also using a mixed proportional hazard specification

$$\theta_p\left(t \middle| x, \tau_0, v_p\right) = \lambda_p(t)\psi_p(\tau_0 + t)exp\left(x'\beta_p + v_p\right)$$

The rate of lowering the list price depends on the same set of observed characteristics x as the rate at which houses are sold and withdrawn.

The use of a flow sample of houses entering the market implies that we do not have any initial-condition problems. The right censoring in the data is independent, and is, therefore, solved in a straightforward manner. In particular, let c_s equal one if a house is observed to be sold, c_w is one if the destination state was withdrawal, and c_p indicates if the list price was reduced. If $i = 1,\ldots, n$ denote the observations, then the loglikelihood function equals

$$\begin{aligned} log\mathscr{L} = \sum_{i=1}^{n} log\Big\{ & \int_{v_s}\int_{v_w}\int_{v_p} \theta_s\left(t_i \middle| x_i, \tau_{0,i}, v_s, t_{p,i}\right)c_{s,i}\theta_w\left(t_i \middle| x_i, \tau_{0,i}, v_w, t_{p,i}\right)c_{w,i} \\ & exp\left(-\int_0^{t_i}\theta_s\left(z \middle| x_i, \tau_{0,i}, v_s, t_{p,i}\right) + \theta_w\left(z \middle| x_i, \tau_{0,i}, v_w, t_{p,i}\right)dz\right) \\ & \theta_p\left(t_{p,i} \middle| x_i, \tau_{0,i}, v_p\right)c_{p,i}exp\left(-\int_0^{t_{p,i}}\theta_p\left(z \middle| x_i, \tau_{0,i}, v_p\right)dz\right)dG\left(v_s, v_l, v_p\right)\Big\} \end{aligned} \quad (1)$$

Where $G(v_s, v_w, v_p)$ is the joint distribution of the unobserved characteristics (v_s, v_w, v_p). If the house was still on the market at the end of the observation period ($c_s = c_w = 0$), then t equals the duration until right-censoring. Furthermore, if during the time on the market no list-price reduction has been observed ($c_p = 0$), then t_p is set equal to the time t the house was on the market (which is the moment of censoring the duration until a list-price reduction).

Abbring and Van den Berg (2003a) provide an extensive discussion on the identification of such models. The key identifying assumption for the causal effects δ_s and δ_w of list-price reductions is that such reductions are not anticipated. Formally, no anticipation of the exact moment of the list-price reduction implies that for $t_d \neq t_d'$ and $t < t_d, t_d'$, it should be that

$$\theta_s\left(t|x, \tau_0, v_s, t_d\right) = \theta_s\left(t \middle| x, \tau_0, v_s, t'_d\right) \text{ and } \theta_w\left(t|x, \tau_0, v_w, t_d\right) = \theta_w\left(t \middle| x, \tau_0, v_w, t'_d\right)$$

This implies that conditional on both observed and unobserved characteristics, the current selling rate and the current rate of withdrawal do not depend on the exact moment of a future list-price reduction. No anticipation does not imply that list-price reductions are exogenous, or that the rate at which list prices are reduced is the same over time. Houses (based on both observed and unobserved characteristics) may have different rates at which list prices are reduced, and it may be that during particular periods a list-price reduction is more likely than in other periods. We explicitly allow for selection on unobservables. Also if some houses never lower the list price (i.e., the duration distribution until lowering the list price is defective), the model is identified.

Within our theoretical framework the no-anticipation assumption imposes that the rate at which buyers visit the house does not respond to the exact timing of future list-price reductions. Buyers are not informed a priori about a list-price reduction. The actual list-price reduction comes as a shock to buyers and is supposed to cause a change in the visit rate. Sellers might already know before in which time period they will change the list price and this might affect the success of a price

[4] Green and Shoven (1986) provide an early application of duration models in real-estate economics.

negotiation. But this it controlled for by the duration dependence term $\lambda_s(t)$.

If the assumption of no anticipation is satisfied, no exclusion restrictions or very strong functional-form restrictions are necessary to identify the causal effects of list-price reductions. However, the no-anticipation assumption is an identifying assumption, which cannot be tested formally using only our data. To provide some intuition for the identification, first note that the data can be broken into two parts: (*i*) a competing-risks part for the duration until a house leaves the market (after being sold or taken off the market) or a lowering of the list price, whichever comes first, and (*ii*) the residual duration from the moment of lowering the list price until the house leaves the market. From Heckman and Honoré (1989) it follows that under general conditions the whole model except for δ_s and δ_w is identified from the data corresponding to the competing-risks part. Abbring and Van den Berg (2003b) show the identification of mixed proportional competing risks models under somewhat milder conditions. Subsequently, δ_s and δ_w are identified from the data corresponding to part (*ii*) of the model, i.e. the residual duration on the market after a list-price reduction. Abbring and Van den Berg (2003a) show that the causal effects of list-price reductions δ_s and δ_w are allowed to depend on t, τ_0, x and v. We exploit this is in the sensitivity analyses discussed in Subsection 5.2.

3.3. Parameterization

The parameterization of our model is similar to the competing-risks model used in Deng et al. (2000). For the duration-dependence functions and the trivariate unobserved-heterogeneity distribution we take the most flexible specifications used to date (e.g. Heckman and Singer, 1984). We take $\lambda_s(t)$, $\lambda_w(t)$ and $\lambda_p(t)$ to have a piecewise-constant specification,

$$\lambda_i(t) = exp\left(\sum_{j=1,2,\ldots} \lambda_{ij} I_j(t)\right) \quad i = s, w, p$$

where j is a subscript for duration intervals, and $I_j(t)$ are time-varying dummy variables that are one in consecutive time intervals. Note that with an increasing number of intervals any duration-dependence pattern can be approximated arbitrarily closely. We normalize the pattern of duration dependence by fixing $\lambda_{i1} = 0$.

We take the joint distribution of the unobserved-heterogeneity terms v_s, v_w and v_p to be trivariate discrete with unrestricted mass-point locations for each term. In particular, we allow for K terms

$$Pr\left(v_s = v_s^k, v_w = v_w^k, v_p = v_p^k\right) = p_k \quad \text{for} \quad k = 1, \ldots, K$$

with $p_1 + \ldots + p_K = 1$. For $K \geq 2$ this specification allows for dependence between the different unobserved-heterogeneity terms. The degree of flexibility increases with K. We do not restrict the locations of the mass points, but instead we normalize the model by not including an intercept in the vector of observed characteristics x.

4. The data

Our data contain all houses and apartments offered for sale through all real-estate brokers associated with the Dutch NVM between January 2005 and December 2007. This covers about 70% of all houses and apartments offered for sale in the Netherlands. For each house (and apartment) we observe the exact date when it was put on the market, and the initial list price. We also observe the exact date at which the house was sold or was taken off the market. If it was still on the market on January 1, 2008, the time on the market is exogenously right censored. Furthermore, we observe the exact dates and the sizes of all revisions of the list price.

For each house, we observe a rich set of characteristics. There is information on the type of house (12 types), the construction period (five periods), parking facility (four types), garden location (nine types), and region (76 regions).[5] Fig. 1 shows the locations of the NVM regions and also the provinces in the Netherlands. The data also include several size characteristics such as the floor size, lot size (in square meters), and the number of rooms in the house. Furthermore, we observe whether the dwelling is well insulated, type of heating system (three types), location next to a quiet road, possible ground lease, presence of an elevator in the apartment building, and two variables measuring inside and outside quality on a discrete scale from one to nine. These quality measures are determined by the real-estate broker selling the house.

Table 1 presents descriptive statistics for the background variables in our data. Houses have, on average, almost five rooms and apartments just over three. The lot size of the average house is 230 m^2 and the floor size 131 m^2. For apartments this is 2 m^2 and 84 m^2, respectively. On a scale from one to ten the quality of both the interior and the exterior is by the real-estate broker ranked slightly above a 7. The correlation between both quality measures is 0.78. The majority of the houses and apartments were built between 1945 and 1990 and most dwellings are terraced houses. Furthermore, most houses and apartments do not have a parking of garage. About 80% of the houses have some garden and only 20% of the apartments. Finally, most houses and apartments are well isolated and are hardly never located next to busy roads.

Table 2 presents some details of the data. In total our data contain 498,369 houses put on the market. For 369,611 houses we observe a sale, 51,092 houses were taken off the market, and 77,666 houses were still on the market at the end of the observation period. On average, the initial list price is €274,367 (although the average initial list price for houses which did sell was substantially lower at €259,410), and the average selling price is €246,614. About 89% of the houses are sold below the list price.

We follow the approach of Merlo and Ortalo-Magné (2004) to compute the list-price premium, which is the difference between the log of the initial list price of the house and the predicted log value of the initial list price of the dwelling. The predicted log value of the list price is based on standard log-linear regressions separately performed for each year (e.g. Rosen, 1974). The R-squared for these regressions are 79.8%, 80.1% and 80.2% for 2005, 2006 and 2007, respectively. The parameter estimates for these regressions are provided in Table 6 in Appendix A. The list-price premium gives us a measure of overpricing or underpricing of the house based on what would be a “normal” list price for the house based on observed characteristics. The average list-price premium for houses which experienced a list-price reduction was 1.82% versus −1.14% for houses which did not experience a list-price reduction.

Fig. 2 shows the Kaplan–Meier estimates for the survival function for selling the house and withdrawing from the market (without sale). When estimating the survivor function for selling the house, censoring due to withdrawing is considered to be independent, and vice versa. This also implies that the probability that a house is still on the market after some duration is the product of the survivor to selling the house and the survivor for withdrawal. If no houses would have been withdrawn before, about 50% of the houses would have been sold after 108 days. Withdrawal is a much slower process, it takes 665 days before the probability of withdrawn reached 0.5.

In total, for 101,896 dwellings we observe a list-price reduction during the period the dwelling was on the market. Only 0.76% of the dwellings for which a list price has been reduced, experience a subsequent reduction in the list price. Therefore, in the empirical analyses we only focus on the first list-price reduction. Fig. 3 shows the survivor function for repricing the house. Within the first 100 days less than 13% of the

[5] Within a NVM region 80% of the families changing house stay within the region.

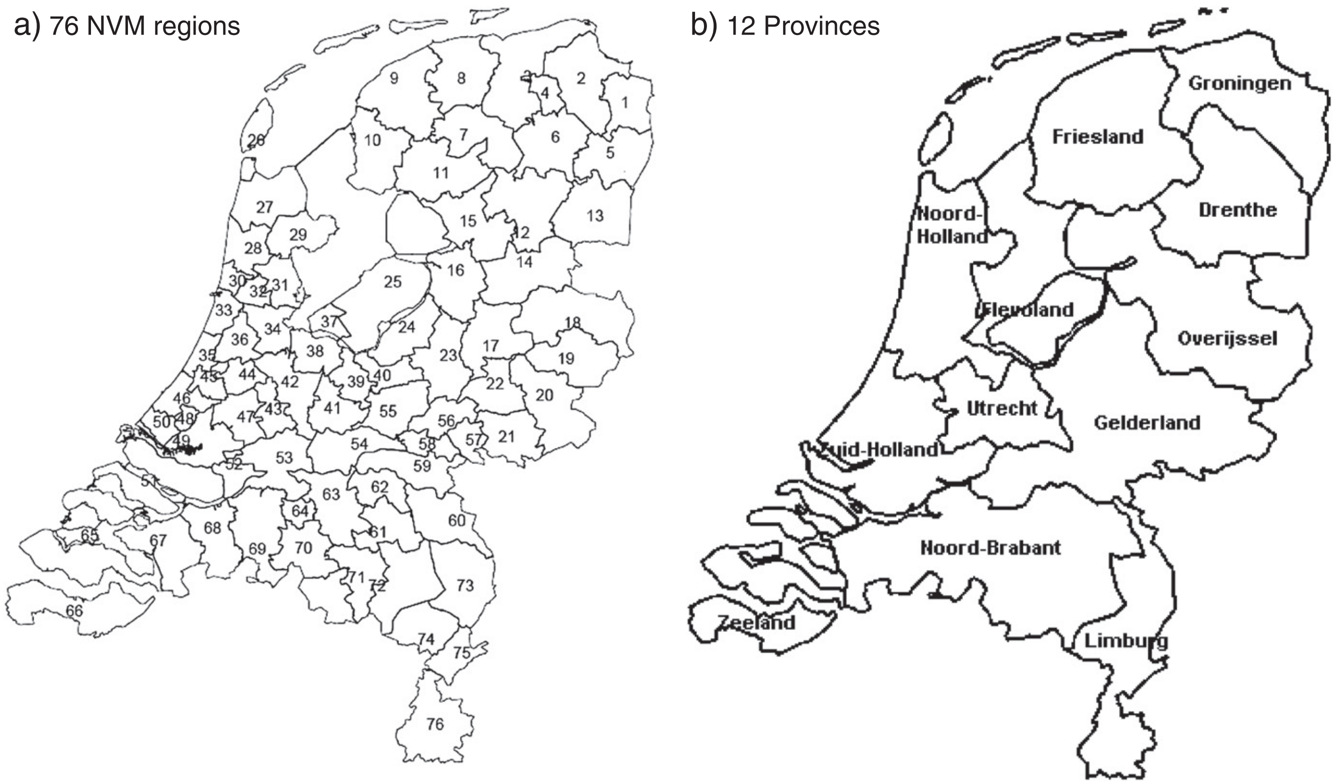

Fig. 1. NVM regions and provinces in the Netherlands.

houses are repriced. After that period the probability of repricing increases. However, it still takes 299 days before the probability of repricing reaches 0.5. If a list price is reduced, the average reduction is 5.5%.

We use the approach by Abbring and Van den Berg (2003c) to provide some first descriptive evidence on whether or not changes in the list price affect the rate of selling a house. The idea is to select houses that are observed to have been sold in a particular duration interval, e.g. houses which were sold after having been on the market between 120 and 125 days. If changing the list price affects the selling rate, for this subsample the hazard of repricing should be upward sloping in the time on the market. The intuition is that if repricing is effective, it should be observed that many list prices have been changes shortly before selling relative to much earlier in the period the house was on the market.[6]

In Fig. 4 we show the hazard of repricing for different subsamples defined by exit duration intervals. The pattern of the different repricing hazards coincides with the case in which repricing has a positive effect on selling the house. For subsamples with longer exit durations the repricing hazard when houses just entered the market is below that of subsamples with shorter exit durations. And more important, for all subsamples the repricing hazard shows an increasing pattern in the time houses are on the market.

Sass (1988) studied the relation between market thinness and list-price reductions. We replicate his empirical analysis to investigate the possible endogeneity of pricing behavior. Therefore, we regress the difference between the list price and the selling price as fraction of the list price on the time the house has been on the market, and indicators for the quality of the house interacted with time on the market. Sass (1988) predicts that more expensive houses (mansions) have a large difference between the list price and selling price, while new houses and houses which were recently previously sold have a small difference. Estimation results using OLS confirm these predictions, which Sass (1988) interprets as evidence that list-price reductions are associated with market thinness and seller's information.

5. Estimation results

5.1. Parameter estimates

In this section we discuss the results of our empirical analysis. First, we present the parameter estimates of our baseline model and provide some model simulations, while in the next subsection we perform sensitivity analyses.

For the piecewise constant duration dependence we choose the following intervals: 0–30 days, 31–60 days, 61–120 days, 121–180 days, 181–270 days, 271–360 days, 361–720 days, and beyond 720 days. However, in the hazard to withdrawing we merge the last two intervals to one interval beyond 361 days, and in the repricing hazard we combine all intervals beyond 181 days. For the unobserved heterogeneity we have three mass points ($K = 3$). We allowed for additional mass points, but the probability mass associated to a fourth point converged towards 0, and the loglikelihood function did not show any improvement. The vector of observed characteristics includes 61 variables.

Table 3 presents the estimates for key parameter of our baseline model (see Table 7 in Appendix B reports all other covariate effects). The main parameter of interest is δ_s, which represents the effect of a list-price reduction on the rate at which a house is sold. The parameter estimates show that a list-price reduction has a positive and significant effect on selling the house. The estimated value of δ_s is 0.606, which implies that after a list-price reduction the rate at which the house is sold increases with $(\exp(0.606) - 1) \times 100\% = 83\%$. Our results indicate that list-price reductions have very substantial effects, which

[6] This argument relies on the no-anticipation assumption, and this approach should not be considered as a test for the validity of the no-anticipation assumption.

Table 1
Descriptive statistics.

	Houses	Apartments	All
Number of rooms	4.9	3.2	4.5
Lot size (in m^2)	230	2	60
Floor size (in m^2)	131	84	115
Quality interior (1–10)	7.1	7.1	7.1
Quality exterior (1–10)	7.1	7.2	7.1
Construction period			
Before 1905	0.0%	0.1%	0.1%
1906–1944	19.4%	22.1%	20.2%
1945–1990	55.4%	55.2%	55.3%
1991–2000	18.7%	13.5%	17.2%
After 2001	6.4%	9.2%	7.2%
Type of house			
Terraced house	39.1%	–	28.2%
Back-to-back housing	2.5%	–	1.8%
Cornerhouse	16.9%	–	12.0%
Semi-detached	19.8%	–	14.1%
Detached	21.4%	–	15.3%
Type of apartment			
Split-level (ground floor)	–	12.6%	3.6%
Split-level (upper floor)	–	27.8%	8.0%
Maisonette	–	9.4%	2.7%
Porch flat	–	31.1%	8.9%
Galary flat	–	18.0%	5.1%
Elderly Flat	–	0.4%	0.1%
Split-level (ground and upper floor)	–	0.8%	0.2%
Parking			
Parking	5.1%	6.9%	5.6%
No parking	53.1%	83.4%	61.7%
Garage	37.8%	4.3%	28.2%
Carport	4.1%	5.4%	4.4%
Garden			
No garden	20.9%	85.8%	39.5%
North side	7.3%	1.0%	5.5%
Norh-east side	6.9%	1.0%	5.2%
East side	9.5%	1.4%	7.2%
South-east side	9.8%	1.7%	7.5%
South side	15.3%	3.3%	11.8%
South-west side	12.1%	2.6%	9.4%
West side	11.1%	2.1%	8.5%
North-west side	7.1%	1.0%	5.3%
Miscellaneous			
Lift	0.1%	31.4%	9.1%
Well isolated	82.8%	73.0%	80.0%
Located to quiet road	50.1%	33.7%	45.4%
Located to busy road	3.3%	6.4%	4.2%
Ground lease	2.7%	15.4%	6.4%
Province			
Groningen	4.6%	4.0%	4.4%
Friesland	5.1%	1.3%	4.0%
Drenthe	4.7%	1.3%	3.7%
Overijssel	7.4%	3.1%	6.2%
Flevoland	3.5%	1.0%	2.8%
Gelderland	14.1%	8.4%	12.4%
Utrecht	8.8%	8.9%	8.8%
Noord-Holland	13.9%	26.1%	17.4%
Zuid-Holland	17.1%	36.2%	22.6%
Zeeland	2.0%	0.6%	1.6%
Noord-Brabant	15.4%	7.6%	13.2%
Limburg	3.4%	1.5%	2.8%

should be interpreted as evidence in favor of asymmetric information between sellers and buyers in the housing market. A list-price reduction also increases the rate at which the house is withdrawn from the market with $(\exp(0.366) - 1) \times 100\% = 44\%$.

Table 2
Some characteristics of the data set.

Number of observations	498,369
Number of sales	369,611
Number of withdrawals	51,092
Number of right censored	77,666
Number of list-price reductions	101,896
Average list-price reduction	5.5%
Average selling price	€246,614
Average list price	€274,367
Average list-price premium:	
for houses which list price was reduced	1.82%
for houses which list price was not reduced	−1.14%

Note.–List-price premium is the difference between the log of the initial list price of the house and the predicted log value of the initial list price of the house. The predicted log value of the list price is based on a log-linear hedonic regression.

The distribution of unobserved heterogeneity shows three mass points. Most probability mass (83%) is located at houses which are sold relatively fast and have a very low rate of withdrawal. These might be regular houses where the seller is determined to sell the house, for example, because the seller already obtained another house. These houses have an average rate of repricing. The second mass point (10% probability) describes houses which both have a high rate of sale and of withdrawal, and also a high rate of repricing. The final 7% probability is located at the third mass point, which describes houses with a low rate of sale and also with a low rate of repricing, but with a high rate of withdrawal. These might be relatively patient sellers or sellers preferring to sell their house first (for a sufficiently high price) before buying a new house. The main conclusion is that there are relevant unobserved characteristics which cause dependency between the three hazards.

There is significant and substantial negative duration dependence in the rate of selling, so it becomes less likely to sell the house the longer it is on the market. This can indicate that houses get stigmatized once they are for sale for a longer period. Stigmatization implies the presence of a characteristic unobserved by buyers which might, for example, be revealed during inspections (e.g. Taylor, 1999). This suggests asymmetric information, but it is not necessary that the seller has more information. There are also alternative explanations. For example, the quality of a house might decline while being on the

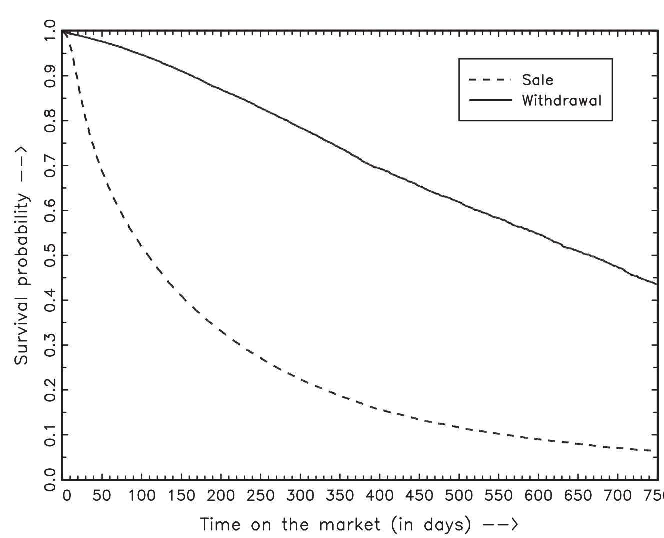

Fig. 2. Kaplan–Meier estimates for the survivor function to selling the house and withdrawal.

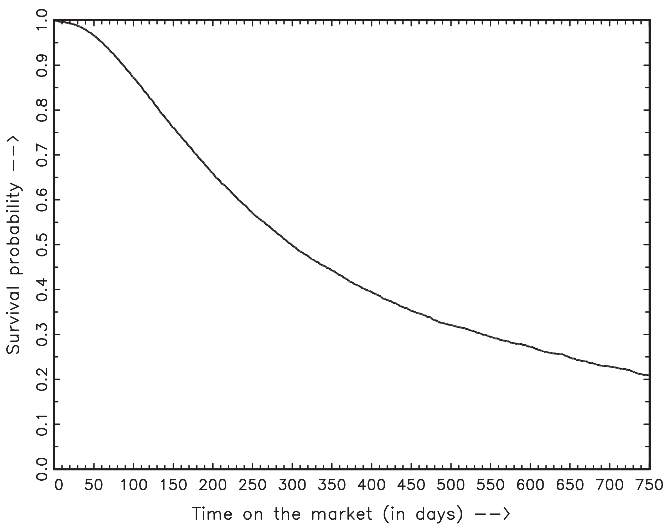

Fig. 3. Kaplan–Meier estimates for the survivor function for reducing the list price.

market. Or it could be that a house which is new on the market is considered by the current stock of all potential buyers. Once they have decided against buying the house, the house can only be sold to new buyers entering the housing market. This argument is the same as in stock-flow matching models for the labor market (e.g. Coles and Smith, 1998). The duration dependence in the rate of withdrawing a house from the market is positive and significant. So the longer the house is on the market the more likely it becomes that the seller withdraws the house. Also there is positive and significant duration dependence in the rate or repricing. Our paper is the first showing empirical evidence in favor of positive duration dependence in repricing. This is consistent with the theory in Lazear (1986), showing that prices decline in time on the market.

To capture the effects of business cycles, we included a flexible time trend containing indicators for each quarter. The parameter estimates show an increasing trend in the rate of selling a house during 2005 and a decreasing trend starting in the second quarter of 2007. There are no significant calendar-time effects in the rate of withdrawing a house. In the rate of repricing a house, there are only significant increases in each second quarter of the year. This is usually the quarter of the year, in which real-estate brokers consider as the best moment of selling a house. It might, therefore be that, real-estate brokers advise sellers to reduce their list price in this quarter. However, the time trend does not show any substantial or unexpected shocks, which coincides with the idea that our observation period is characterized by relatively stable market conditions.

In the estimation we also included the list-price premium as explanatory variable. Recall that the list-price premium is defined as the list price of the house compared to a hedonic list price for the house. A positive list-price premium implies that the house is priced higher than comparable houses in the market. No strong causal interpretation should be given to the covariate effects of the list-price premium. However, the estimation results are consistent with most theoretical predictions (e.g. Lazear, 1986). Like Genesove and Mayer (1997) we find that houses with a higher list-price premium are less likely to be sold, are more likely to be withdrawn from the market, and more likely to be repriced (see also Genesove and Mayer, 2001). These results (and also all other parameter estimates) are robust against alternative specification of the list-price premium, for example, the list price relative to the hedonic selling price.

A list-price reduction has a positive and significant effect on both the rate at which houses are sold and withdrawn from the market. The changes in these rates are quite substantial. In Table 4 we present how these effects translate in the probability of selling and withdrawing a house from the market. In particular, we consider list-price changes after a house has been on the market for one month (30 days), one quarter (91 days) or half a year (182 days), and we focus on selling or withdrawing the house within one quarter, half a year and one year (365 days). In the model calculations we only take into account houses entering the market in 2005 and 2006.[7]Column (1) shows that if list prices is never reduced about 44% of all houses are sold within one quarter (and 3.2% of the houses are withdrawn from the market). A list-price reduction after one month increases the percentage of houses sold within one quarter to almost 57% (see Column (2)). This is substantial, particularly since after 30 days only about 79% of the houses are still on the market. A list-price reduction also increases withdrawing the house from the market. However, a late list-price reduction after 182 days compared to 30 days has a more substantial effect on withdrawing the house than selling the house within 365 days (see Column (2) and (4)). In the next subsection we focus more on the importance of the timing of a list-price reduction.

5.2. Sensitivity analyses

In this subsection we examine the robustness of our parameter estimates with respect to the model specification. We provide a number of sensitivity analyses, and mainly focus on the effects of list-price reductions.

In the first sensitivity analysis we consider the importance of allowing for dependence between the different hazard rates. Independent hazards implies that the unobserved heterogeneity components in the three hazard rates are independent of each other. Note that this does not mean that unobserved heterogeneity is absent from the model. From the first panel in Table 5 it can be seen that not correcting for dependence between the hazards causes an increase in the estimated effects of the list-price reductions. Compared to the baseline model the effect of a list-price reduction on selling the house increases from 0.606 to 0.771, and given the small standard errors these effects are statistically different from each other. The effect on withdrawing increases

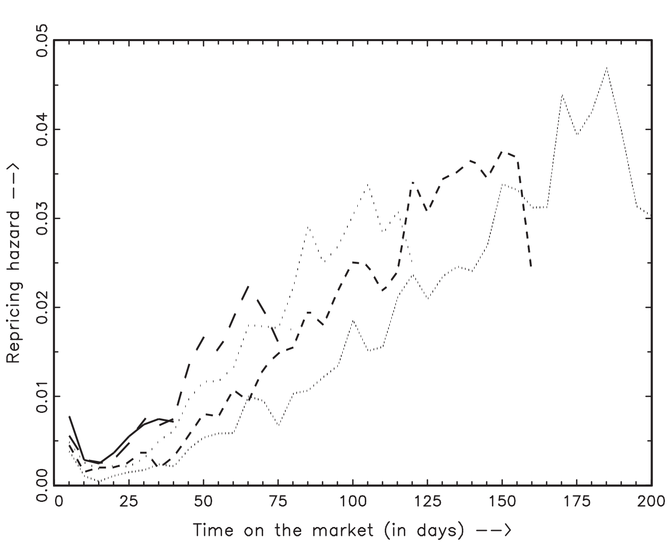

Fig. 4. Repricing hazard for different subsamples defined by exit duration intervals.

[7] In the model calculations we follow houses for at most one year. Since we modeled business-cycle effects using quarterly dummies, we cannot say anything beyond January 1, 2008 without imposing some arbitrary extrapolation. Therefore, in the model calculations we ignore houses entering the market in 2007.

Table 3
Estimation results of the baseline model.

	Sale hazard θ_s		Exit hazard θ_w		Repricing hazard θ_p	
Effect of repricing δ	0.606	(0.026)	0.366	(0.075)		
Unobserved heterogeneity						
υ_1	−2.739	(0.970)	−13.901	(1012.179)	−12.577	(1.898)
υ_2	−2.789	(0.756)	−7.720	(1.650)	−12.146	(1.403)
υ_3	−4.120	(0.764)	−7.847	(1.639)	−13.675	(1.406)
p_1	0.834	(0.355)				
p_2	0.103	(0.017)				
p_3	0.062	(0.754)				
Duration dependence						
λ_0 (0–30 days)	0		0		0	
λ_1 (31–60 days)	0.033	(0.016)	0.069	(0.062)	1.167	(0.053)
λ_2 (61–120 days)	−0.268	(0.017)	0.322	(0.058)	1.874	(0.049)
λ_3 (121–180 days)	−0.441	(0.022)	0.595	(0.067)	2.193	(0.053)
λ_4 (181–270 days)	−0.502	(0.027)	0.698	(0.078)	2.383	(0.061)
λ_5 (271–360 days)	−0.498	(0.037)	0.833	(0.096)	…	
λ_6 (361–720 days)	−0.448	(0.049)	0.977	(0.122)	…	
λ_7 (>720 days)	−0.524	(0.125)	…		…	
Calendar-time effects						
2005-Q1	0		0		0	
2005-Q2	0.055	(0.039)	0.109	(0.135)	0.226	(0.107)
2005-Q3	0.144	(0.039)	−0.185	(0.134)	0.035	(0.105)
2005-Q4	0.211	(0.038)	−0.035	(0.131)	0.094	(0.105)
2006-Q1	0.239	(0.039)	0.142	(0.129)	0.107	(0.105)
2006-Q2	0.196	(0.038)	0.038	(0.130)	0.249	(0.104)
2006-Q3	0.155	(0.039)	−0.064	(0.130)	0.034	(0.105)
2006-Q4	0.140	(0.039)	0.034	(0.129)	0.093	(0.104)
2007-Q1	0.209	(0.039)	0.133	(0.128)	0.171	(0.104)
2007-Q2	0.177	(0.038)	0.087	(0.128)	0.301	(0.104)
2007-Q3	0.083	(0.039)	0.110	(0.128)	0.038	(0.105)
2007-Q4	0.067	(0.039)	0.107	(0.128)	0.143	(0.104)
List-price premium	−0.632	(0.031)	0.106	(0.076)	0.228	(0.057)
Additional controls	Yes		Yes		Yes	
Log likelihood			−3,401,344.37			
Observations			498,369			

Note.–List-price premium is the difference between the log of the initial list price of the house and the predicted log value of the initial list price of the house. The predicted log value of the list price is based on a log-linear hedonic regression. Additional controls are for number of rooms, log(lot size), log(lot size) squared, log(floor size), log(floor size) squared, construction period, type of house (or type of apartment), presence of a lift in the apartment building, parking facility, garden location, isolation, location to busy roads, ground lease, inside and outside quality of the house, and regions. Standard errors are in parentheses.

from 0.370 in the baseline model to 0.405. These results show the importance of self selection in the decision to reduce the list price. Obviously houses with a lower rate of selling are more likely to be repriced, which confirms the argument of Caplin and Leahy (1996) that self selection matters in markets with frictions.

Next, we consider the size of the list-price reduction. Therefore, we interact the effect of the list-price reductions with the magnitude of the list-price reduction, measured as fraction decrease in the list price. The specification of the effect of a list-price reduction is thus $\delta_0 + \delta_1 \Delta P$, where ΔP is the size of the list-price reduction. The second panel in Table 5 shows that the size of the list-price reduction has a positive and significant effect on selling the house. If the list price is more substantial, the effect of the list-price reduction is larger. Recall

Table 4
Predicted probabilities for the baseline model.

	Moment of repricing			
	(1)	(2)	(3)	(4)
	Never	30 days	91 days	182 days
In market at repricing		79.4%	52.8%	33.5%
Sold within 91 days	44.0%	56.7%	44.0%	44.0%
Withdrawn within 91 days	3.2%	4.2%	3.2%	3.2%
Sold within 182 days	60.7%	73.9%	68.6%	60.7%
Withdrawn within 182 days	5.9%	7.2%	7.1%	5.9%
Sold within 365 days	74.8%	83.5%	81.6%	79.5%
Withdrawn within 365 days	9.7%	10.3%	11.0%	11.0%

Note.–Only houses entering the market in 2005 and 2006 are taken into account.

Table 5
Sensitivity analyses on the effect of list-price reductions.

	Sale hazard θ_s		Exit hazard θ_w		Transaction price	
Independent hazards						
Effect of repricing: δ	0.771	(0.016)	0.405	(0.036)		
Repricing interacted with magnitude						
Effect of repricing: δ_0	0.506	(0.025)	0.370	(0.060)		
Interaction with magnitude δ_1	2.270	(0.290)	−0.164	(0.600)		
Moment of repricing						
Repricing within 60 days δ_1	0.464	(0.032)	0.650	(0.076)		
Repricing between 60 and 182 days δ_2	0.649	(0.026)	0.330	(0.060)		
Repricing after 182 days δ_3	0.762	(0.034)	0.150	(0.072)		
Model with transaction price						
Effect of repricing δ_1	0.603	(0.020)	0.400	(0.046)	0.308	(0.020)
Days on the market δ_2					0.00216	(0.00008)

Note.–Similar specification and controls as in the baseline model. Full sets of parameter estimates are available on request. Standard errors are in parentheses.

from Section 4 that the average list-price reduction in the data is 5.5%. So for the average list-price reduction the effect on the hazard of sale is 0.630, which is not very different from the homogeneous effect estimated in our baseline model. The size of the list-price reduction does not have a significant effect on the rate of withdrawing the house from the market. Although these results provide some indication about the effects, it is difficult to draw strong causal conclusions. The size of the list-price reduction is most likely endogenous which is not taken into account in our model.

Next, we want to know if the timing of the list-price reduction is important. So does a list-price reduction if the house is only shortly on the market have a different effect than a list-price reduction if the house is already for sale for a longer period. Therefore, we allow the effect to depend on time on the market. In particular, we allow the effect to be different within three time intervals, (*i*) within the first 60 days, (*ii*) between 60 days and 182 days, and (*iii*) after 182 days on the market. The third panel in Table 5 shows that the effect of a list-price reduction on the hazard of selling the house increases in time on the market, while the opposite is the case in the hazard of withdrawing. However, recall that we found negative duration dependence in the selling hazard and positive duration in the rate of withdrawing the house from the market. So in absolute terms the change in selling and withdrawing probabilities due to list-price reductions do not vary that much in the timing of the list-price reduction.

A list-price reduction reduces the average duration until selling a house. In a housing market with asymmetric information, time on the market may be a negative signal and negatively affect the selling price. Other than this indirect effect, list-price reductions can also have a direct effect on the transaction price simply because a list-price reduction provides a signal to the market. A first indication is that houses with an observed list-price reduction are sold, on average, 3.6% below their hedonic value, while houses without a list-price reduction are sold 0.9% above their hedonic value. However, we showed above that there are also unobserved characteristics affecting the decision to reduce the list price. To take this into account we extend our model with a model for transaction prices. We use also a hazard-rate model for the transaction prices p, with the density function

$$f_t\left(p\middle|t_p,t,\tau_0,x,v_t\right)=\theta_t\left(p\middle|t_p,t,\tau_0,x,v_t\right)exp\left(-\int_0^p\theta_t\left(s\middle|t_p,t,\tau_0,x,v_t\right)ds\right)$$

with

$$\theta_t\left(p\middle|t_p,t,x,v_t\right)=\lambda_t(p)\psi_t(\tau_0+t)exp\left(x'\beta_t+\delta_{t,1}\cdot I\left(t_p<t\right)+\delta_{t,2}\cdot t+v_t\right)$$

So $\psi_t(\tau_0+t)$ denotes calendar-time effects at the moment of selling the house, $I(t_p<t)$ describes if the list price was reduced while the house was on the market, and t is the time the house was on the market before being sold. We estimate this model for transaction prices jointly with the models for selling, withdrawing and repricing. By interacting the unobserved-heterogeneity terms in the different hazard rates we allow for dependence between these hazard rates. This also implies that in the model for the selling price both the list-price reduction and the duration until selling the house are endogenous. The parameters of interest are the direct effect of a list-price reduction $\delta_{t,1}$, and $\delta_{t,2}$ capturing the effect of time on the market on the transaction price. Using a hazard rate model for transaction prices follows Donald et al. (2000) who present hazard-rate specifications as very flexible models for wages.

The bottom panel of Table 5 shows the estimation results for the main parameters of interest. First, jointly modeling the transaction price hardly changes the parameter estimates obtained from the baseline model. The parameter estimate of a list-price reduction on the hazard for the transaction price is positive, which implies that a list-price reduction reduces the expected transaction price. This confirms the finding of Deng et al. (2009), who find that the transaction price is lower after a list-price reduction. There is thus a substantial disadvantage to the seller of reducing the list price. However, also the coefficient of the time on the market is positive, implying that the expected transaction price reduces in the time the house was on the market before selling it. However, only if the list-price reduction reduces the time on the market with more that $\frac{0.308}{0.00216}\approx 143$ days, the indirect effect dominates the direct effect on the transaction price.

Finally, Haurin (1988) distinguishes between regular houses and atypical houses. We also consider this distinction. First, we include a dummy variable for atypical houses (using the Haurin, 1988; measure) in our model. This does not change any of the estimation results. In particular, the effects of the list-price reductions are unaffected. Second, we estimate the model again without atypical houses, which excludes 10% of the data. The effect of the repricing slightly changes to 0.598 (s.e. 0.028) on the hazard of sale and 0.364 (s.e. 0.078) on the hazard of withdrawal. This indicates that our results are not driven by atypical houses changing list prices, but also hold in the market for regular houses.

6. Conclusions

The main focus of this paper is on the effect of lowering list prices on the time at which a house is on the market. In our empirical model we explicitly allow for selectivity in list-price reductions. We also take into account that houses can also be taken off the market without being sold and that such exits might not be exogenous. Our model is a timing-of-events model described in Abbring and Van den Berg (2003a).

Our empirical results show that list-price reductions significantly increase the hazard of sale, but also increase the hazard at which the house is taken off the market. The effects are very substantial. A list-price reduction raises the selling rate by 83%, and the rate of withdrawing by 44%. Since list prices do not have any formal legal role in the Dutch housing market, list prices can only be used by the seller to provide signals to the market. In a market with symmetric information, signals do not add any information. Therefore, we interpret the substantial and significant effect of the list-price reductions as evidence in favor of the presence of asymmetric information in the housing market.

In the sensitivity analyses, we have also shown that the timing and the magnitude of the list-price reduction matter. Furthermore, we have stressed the importance of allowing for selectivity in list-price reductions and taking withdrawals from the market into account. Our results confirm the argument made by Caplin and Leahy (1996) that self-selection matters in markets with frictions. Finally, we have investigated the effect of list-price reductions on the transaction price. List-price reductions reduce the expected transaction price, which is the direct effect. However, also the time on the market before selling the house has a negative effect on the transaction price. The indirect effect of a list-price reduction is that it reduced the time on the market which again increases the expected transaction price.

We have found negative duration dependence in the hazard of sale, which might also be the consequence of houses getting stigmatized due to the presence of asymmetric information. The parameter estimates show positive duration dependence in the rate of withdrawal and the repricing hazard. This paper is the first finding empirical evidence in favor of positive duration dependence in the hazard of repricing, which is consistent with Lazear (1986). Also the finding that higher list prices increase the likelihood of list-price reductions is consistent with Lazear (1986), although our estimate for the latter is only an association not necessarily a casual effect.

Appendix A. Hedonic list-price regressions

Table 6
Estimation results of hedonic list-price regressions for 2005–2007.

	2005		2006		2007	
Constant	7.815	(0.013)	7.837	(0.013)	7.724	(0.013)
Size characteristics						
Number of rooms	0.011	(0.001)	0.011	(0.001)	0.011	(0.001)
loglotsize	0.018	(0.000)	0.018	(0.000)	0.046	(0.001)
logfloorsize	0.838	(0.003)	0.844	(0.003)	0.841	(0.003)
Construction period (1991–2000 is base)						
Before 1905	0.045	(0.024)	−0.029	(0.027)	0.014	(0.028)
1906–1944	−0.048	(0.002)	−0.045	(0.002)	−0.037	(0.002)
1945–1990	−0.102	(0.001)	−0.108	(0.001)	−0.115	(0.001)
After 2001	0.009	(0.003)	0.003	(0.003)	0.001	(0.002)
Type of house (terraced house is base)						
Back-to-back housing	0.079	(0.004)	0.076	(0.004)	0.097	(0.004)
Corner house	0.047	(0.002)	0.046	(0.002)	0.032	(0.002)
Semi-detached	0.157	(0.002)	0.153	(0.002)	0.126	(0.002)
Detached	0.363	(0.002)	0.364	(0.002)	0.315	(0.002)
Type of apartment						
Split-level (ground floor)	0.153	(0.004)	0.160	(0.004)	0.307	(0.004)
Split-level (upper floor)	0.064	(0.003)	0.067	(0.003)	0.218	(0.004)
Maisonette	0.010	(0.004)	0.006	(0.004)	0.157	(0.005)
Porch flat	0.068	(0.003)	0.063	(0.003)	0.214	(0.004)
Galary flat	0.011	(0.004)	0.024	(0.004)	0.168	(0.004)
Elderly flat	−0.471	(0.012)	−0.527	(0.013)	−0.233	(0.017)
Split-level (ground and upper floor)	0.113	(0.012)	0.131	(0.012)	0.292	(0.012)
Parking (no parking is base)						
Parking	0.056	(0.003)	0.063	(0.002)	0.063	(0.002)
Garage	0.113	(0.002)	0.111	(0.002)	0.109	(0.002)
Carport	0.114	(0.003)	0.119	(0.003)	0.118	(0.003)
Garden (south-east is base)						
No garden	0.021	(0.002)	0.025	(0.002)	0.024	(0.002)
North side	−0.017	(0.003)	−0.016	(0.003)	−0.011	(0.003)
North-east side	−0.009	(0.003)	−0.007	(0.003)	−0.007	(0.003)
East side	−0.014	(0.003)	−0.015	(0.003)	−0.013	(0.003)
South side	−0.001	(0.003)	0.000	(0.003)	0.000	(0.003)
South-west side	0.004	(0.003)	0.009	(0.003)	0.009	(0.003)
West side	−0.009	(0.003)	−0.009	(0.003)	−0.010	(0.003)
North-west side	−0.005	(0.003)	−0.001	(0.003)	0.002	(0.003)
Miscellaneous						
Lift	0.085	(0.002)	0.068	(0.002)	0.060	(0.002)
Well isolated	−0.006	(0.001)	−0.009	(0.001)	−0.016	(0.002)
Located to quiet road	0.006	(0.001)	0.003	(0.001)	0.006	(0.001)
Located to busy road	−0.011	(0.003)	−0.011	(0.003)	−0.009	(0.003)
Ground lease	−0.083	(0.003)	−0.111	(0.002)	−0.115	(0.002)
Quality interior	0.037	(0.001)	0.036	(0.001)	0.038	(0.001)
Quality exterior	0.012	(0.001)	0.010	(0.001)	0.011	(0.001)
Month dummies (January is base)						
February	0.004	(0.003)	0.002	(0.003)	0.006	(0.003)
March	0.013	(0.003)	0.009	(0.003)	0.016	(0.003)
April	0.019	(0.003)	0.015	(0.003)	0.025	(0.003)
May	0.025	(0.003)	0.024	(0.003)	0.034	(0.003)
June	0.022	(0.003)	0.026	(0.003)	0.035	(0.003)
July	0.015	(0.003)	0.024	(0.003)	0.037	(0.003)
August	0.023	(0.003)	0.030	(0.003)	0.035	(0.003)
September	0.029	(0.003)	0.031	(0.003)	0.048	(0.003)
October	0.029	(0.003)	0.035	(0.003)	0.046	(0.003)
November	0.028	(0.003)	0.037	(0.003)	0.050	(0.003)
December	0.030	(0.003)	0.034	(0.003)	0.047	(0.003)
Region (Apeldoorn a.s. is base)						
Region 01 Noordoost-Groningen	−0.527	(0.010)	−0.536	(0.010)	−0.535	(0.010)
Region 02 Slochteren a.s.	−0.475	(0.007)	−0.479	(0.007)	−0.485	(0.007)
Region 03 Grootegast a.s.	−0.371	(0.007)	−0.359	(0.008)	−0.353	(0.007)
Region 04 Stad Groningen a.s.	−0.122	(0.006)	−0.100	(0.006)	−0.086	(0.006)
Region 05 Zuidoost-Groningen	−0.472	(0.010)	−0.457	(0.009)	−0.478	(0.009)
Region 06 Noord-Drenthe	−0.302	(0.007)	−0.296	(0.007)	−0.302	(0.007)
Region 07 Opsterland	−0.342	(0.008)	−0.334	(0.008)	−0.328	(0.008)

(continued on next page)

Table 6 (*continued*)

	2005		2006		2007	
Constant	7.815	(0.013)	7.837	(0.013)	7.724	(0.013)
Region (Apeldoorn a.s. is base)						
Region 08 Oost-Friesland	−0.337	(0.009)	−0.341	(0.009)	−0.325	(0.009)
Region 09 Noordwest-Friesland	−0.278	(0.006)	−0.268	(0.006)	−0.279	(0.006)
Region 10 Zuidwest-Friesland	−0.172	(0.008)	−0.190	(0.008)	−0.207	(0.008)
Region 11 Zuid-Friesland	−0.221	(0.008)	−0.213	(0.008)	−0.232	(0.008)
Region 12 Zuidwest-Drenthe	−0.277	(0.008)	−0.259	(0.008)	−0.255	(0.008)
Region 13 Zuidoost-Drenthe	−0.406	(0.007)	−0.407	(0.007)	−0.410	(0.007)
Region 14 Hardenberg a.s.	−0.225	(0.008)	−0.212	(0.009)	−0.231	(0.009)
Region 15 Kop van Overijssel	−0.148	(0.008)	−0.160	(0.009)	−0.162	(0.009)
Region 16 Zwolle a.s.	−0.023	(0.006)	−0.019	(0.006)	−0.026	(0.006)
Region 17 Raalte a.s.	−0.093	(0.007)	−0.099	(0.007)	−0.096	(0.007)
Region 18 Almelo Tubbergen	−0.236	(0.007)	−0.241	(0.007)	−0.259	(0.007)
Region 19 Hengelo Enschede	−0.274	(0.006)	−0.263	(0.006)	−0.271	(0.006)
Region 20 Ruurlo Eibergen	−0.181	(0.008)	−0.197	(0.008)	−0.212	(0.008)
Region 21 Doetinchem a.s.	−0.133	(0.008)	−0.139	(0.008)	−0.172	(0.008)
Region 22 Zutphen a.s.	−0.031	(0.008)	−0.014	(0.008)	−0.040	(0.008)
Region 24 Nunspeet a.s.	0.073	(0.007)	0.087	(0.007)	0.083	(0.007)
Region 25 Lelystad	−0.232	(0.006)	−0.235	(0.007)	−0.249	(0.007)
Region 26 Den Helder Texel	−0.195	(0.011)	−0.204	(0.010)	−0.196	(0.010)
Region 27 Kop van Noord-Holland	−0.122	(0.009)	−0.121	(0.010)	−0.121	(0.010)
Region 28 Noord-Kennemerland	0.069	(0.006)	0.072	(0.006)	0.088	(0.006)
Region 29 West-Friesland	−0.135	(0.008)	−0.121	(0.008)	−0.112	(0.007)
Region 30 Midden-Kennemerland	0.103	(0.008)	0.085	(0.008)	0.076	(0.008)
Region 31 Waterland	0.097	(0.007)	0.113	(0.007)	0.122	(0.007)
Region 32 Zaanstreek	0.050	(0.007)	0.046	(0.007)	0.050	(0.007)
Region 33 Zuid-Kennemerland	0.242	(0.006)	0.259	(0.006)	0.301	(0.006)
Region 34 Amsterdam	0.375	(0.005)	0.421	(0.005)	0.474	(0.005)
Region 35 De Bollenstreek	0.254	(0.007)	0.246	(0.007)	0.255	(0.007)
Region 36 Haarlemmermeer	0.131	(0.006)	0.143	(0.007)	0.152	(0.007)
Region 37 Almere	−0.167	(0.006)	−0.180	(0.007)	−0.173	(0.007)
Region 38 Het Gooi	0.280	(0.006)	0.305	(0.006)	0.322	(0.006)
Region 39 Amersfoort	0.098	(0.006)	0.119	(0.006)	0.117	(0.006)
Region 40 Barneveld	0.074	(0.009)	0.097	(0.010)	0.090	(0.009)
Region 41 Bunnik Zeist	0.220	(0.006)	0.233	(0.006)	0.239	(0.006)
Region 42 Utrecht	0.160	(0.005)	0.185	(0.005)	0.217	(0.005)
Region 43 Woerden	0.181	(0.009)	0.173	(0.009)	0.173	(0.009)
Region 44 Alphen	0.110	(0.007)	0.106	(0.008)	0.122	(0.008)
Region 45 Leiden	0.251	(0.006)	0.263	(0.006)	0.269	(0.006)
Region 46 Den Haag	0.071	(0.005)	0.090	(0.005)	0.092	(0.005)
Region 47 Gouda	0.077	(0.006)	0.076	(0.006)	0.079	(0.007)
Region 48 Delft a.s.	0.142	(0.008)	0.163	(0.008)	0.165	(0.008)
Region 49 Rotterdam	0.005	(0.005)	0.004	(0.005)	−0.002	(0.005)
Region 50 Westland	0.153	(0.008)	0.161	(0.008)	0.149	(0.008)
Region 51 Brielle Goeree	−0.035	(0.006)	−0.026	(0.006)	−0.021	(0.006)
Region 52 Dordrecht	−0.028	(0.006)	−0.025	(0.006)	−0.021	(0.006)
Region 53 Gorinchem	0.035	(0.008)	0.047	(0.008)	0.041	(0.008)
Region 54 Culemborg Dodewaard	−0.035	(0.007)	−0.016	(0.007)	0.005	(0.007)
Region 55 Ede a.s.	0.054	(0.006)	0.067	(0.007)	0.071	(0.006)
Region 56 Arnhem	−0.016	(0.006)	−0.020	(0.006)	−0.024	(0.006)
Region 57 Duiven Westervoort	−0.123	(0.008)	−0.117	(0.009)	−0.132	(0.008)
Region 58 Elst a.s.	−0.043	(0.008)	−0.041	(0.008)	−0.074	(0.008)
Region 59 Nijmegen	0.022	(0.006)	0.031	(0.006)	0.030	(0.006)
Region 60 Noordoost-Brabant	−0.142	(0.009)	−0.134	(0.009)	−0.132	(0.009)
Region 61 Uden a.s.	0.007	(0.008)	0.013	(0.008)	0.015	(0.008)
Region 62 Oss a.s.	−0.067	(0.008)	−0.079	(0.009)	−0.081	(0.009)
Region 63 Den Bosch	0.079	(0.006)	0.090	(0.006)	0.083	(0.006)
Region 64 Waalwijk Drunen	0.002	(0.010)	0.019	(0.010)	0.020	(0.009)
Region 65 Zeeuwse Eilanden	−0.109	(0.007)	−0.109	(0.007)	−0.115	(0.007)
Region 66 Zeeuws-Vlaanderen	−0.456	(0.009)	−0.439	(0.009)	−0.415	(0.009)
Region 67 Bergen op Zoom a.s.	−0.081	(0.009)	−0.081	(0.009)	−0.099	(0.009)
Region 68 West-Brabant	−0.071	(0.008)	−0.060	(0.008)	−0.043	(0.008)
Region 69 Breda	0.013	(0.006)	0.025	(0.006)	0.049	(0.006)
Region 70 Tilburg Oirschot	−0.028	(0.006)	−0.011	(0.006)	−0.023	(0.006)
Region 71 Eindhoven a.s.	0.015	(0.006)	0.039	(0.006)	0.054	(0.006)
Region 72 Zuidoost-Brabant	−0.104	(0.007)	−0.085	(0.007)	−0.059	(0.007)
Region 73 Noord-Limburg	−0.241	(0.009)	−0.254	(0.009)	−0.279	(0.009)
Region 74 Weert a.s.	−0.227	(0.009)	−0.244	(0.009)	−0.254	(0.009)
Region 75 Roermond a.s.	−0.334	(0.011)	−0.351	(0.010)	−0.365	(0.009)
Region 76 Zuid-Limburg	−0.292	(0.007)	−0.289	(0.006)	−0.299	(0.006)
Adjusted R^2	0.798		0.801		0.802	
Number of observations	169,932		170,697		176,651	

Note.–The dependent variable is log(list price). Standard errors are in parentheses.

Appendix B. Estimated covariate effects of baseline model

Table 7
Estimated covariate effects for the baseline model.

	Sale hazard θ_s		Exit hazard θ_w		Repricing hazard θ_p	
Size characteristics						
Rooms	0.038	(0.006)	0.002	(0.013)	0.013	(0.011)
Loglotsize	−0.035	(0.010)	0.028	(0.023)	0.051	(0.020)
Loglotsize^2	0.007	(0.001)	0.000	(0.003)	−0.006	(0.003)
Logfloorsize	−0.349	(0.313)	−0.400	(0.661)	2.137	(0.575)
Logfloorsize^2	−0.016	(0.033)	0.065	(0.068)	−0.257	(0.059)
Construction period (1991–2000 is base)						
Before 1905	0.720	(0.426)	0.838	(0.657)	0.332	(1.097)
1906–1944	0.081	(0.019)	0.039	(0.045)	0.208	(0.035)
1945–1990	0.056	(0.015)	−0.103	(0.037)	0.105	(0.028)
After 2001	−0.285	(0.028)	−0.083	(0.057)	−0.186	(0.046)
Type of house (terraced house is base)						
Back-to-back housing	−0.244	(0.048)	0.016	(0.121)	−0.074	(0.082)
Cornerhouse	−0.115	(0.020)	−0.020	(0.055)	−0.039	(0.038)
Semi-detached	−0.214	(0.021)	−0.124	(0.057)	−0.070	(0.039)
Detached	−0.747	(0.026)	−0.154	(0.064)	−0.411	(0.046)
Type of apartment						
Split-level (ground floor)	−0.046	(0.040)	0.468	(0.098)	0.099	(0.078)
Split-level (upper floor)	0.010	(0.035)	0.516	(0.082)	0.075	(0.068)
Maisonette	−0.176	(0.045)	0.246	(0.107)	−0.077	(0.087)
Porch flat	−0.104	(0.037)	0.219	(0.089)	0.008	(0.071)
Galary flat	−0.044	(0.043)	0.216	(0.106)	0.138	(0.081)
Elderly flat	−0.924	(0.182)	−0.011	(0.406)	−1.586	(0.443)
Split-level (ground and upper floor)	−0.211	(0.131)	0.550	(0.247)	0.227	(0.184)
Parking (no parking is base)						
Parking	−0.113	(0.026)	−0.094	(0.062)	−0.059	(0.047)
Garage	−0.111	(0.017)	−0.124	(0.041)	−0.043	(0.030)
Carport	−0.170	(0.031)	−0.191	(0.072)	−0.049	(0.052)
Garden (south-east is base)						
No garden	−0.097	(0.025)	0.167	(0.068)	−0.045	(0.048)
North side	−0.104	(0.032)	0.149	(0.088)	−0.021	(0.059)
Norh-east side	−0.066	(0.032)	0.094	(0.088)	0.005	(0.061)
East side	−0.046	(0.029)	0.074	(0.082)	−0.001	(0.056)
South side	−0.012	(0.026)	0.061	(0.074)	0.035	(0.050)
South-west side	0.028	(0.028)	0.121	(0.077)	0.034	(0.053)
West side	−0.035	(0.028)	0.071	(0.080)	−0.046	(0.054)
North-west side	−0.006	(0.032)	0.095	(0.089)	0.004	(0.062)
Miscellaneous						
Lift	−0.163	(0.026)	−0.041	(0.060)	−0.146	(0.048)
Well isolated	−0.084	(0.015)	−0.212	(0.036)	−0.063	(0.028)
Located to quiet road	0.079	(0.012)	0.026	(0.031)	0.081	(0.022)
Located to busy road	−0.118	(0.030)	0.144	(0.065)	−0.008	(0.051)
Ground lease	0.026	(0.025)	0.115	(0.060)	−0.033	(0.048)
Quality interior	−0.053	(0.009)	0.043	(0.023)	−0.004	(0.017)
Quality exterior	0.047	(0.010)	0.041	(0.026)	0.003	(0.019)
(*Noord-Holland*)						
Groningen	0.115	(0.031)	−0.245	(0.085)	−0.039	(0.058)
Friesland	−0.047	(0.016)	−0.160	(0.042)	−0.075	(0.029)
Drenthe	−0.024	(0.012)	−0.077	(0.027)	−0.101	(0.021)
Overijssel	−0.060	(0.007)	−0.122	(0.018)	−0.069	(0.013)
Flevoland	−0.049	(0.008)	−0.002	(0.016)	−0.075	(0.014)
Gelderland	−0.017	(0.004)	−0.057	(0.009)	−0.047	(0.007)
Utrecht	0.027	(0.003)	−0.025	(0.009)	0.003	(0.007)
Zuid-Holland	−0.026	(0.002)	−0.027	(0.005)	−0.022	(0.004)
Zeeland	−0.025	(0.005)	−0.027	(0.012)	−0.010	(0.008)
Noord-Brabant	0.006	(0.002)	−0.028	(0.005)	−0.015	(0.004)
Limburg	−0.026	(0.003)	0.003	(0.007)	−0.025	(0.006)
Log likelihood			−3,401,344.37			
Observations			498,369			

Note.–Standard errors are in parentheses.

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