Liquidity and price discovery in real estate assets

de Wit, E.R.

This dissertation covers three empirical essays on the housing market. Although we limit ourselves to the housing market, the findings might be relevant for other sectors of the real estate market or any other market that is characterized by illiquidity, indivisibility of goods and a high level of heterogeneity between goods. Chapter two tests whether the empirical predictions from housing market models with asymmetric information are true. Specifically, we test whether the probability that a house will sell will decline with the time the house has already spent on the market, and the probability that a house will be withdrawn from the market will increase with the time the house has already spent on the market. Chapter three considers the role of the list price in the housing market. List prices would have no role in a housing market with symmetric information between sellers and buyers and the probability of a sale would not be affected by reductions in the list price. Based on this observation we test for the presence of asymmetric information between sellers and buyers in the housing market by testing whether reductions in the list price affect the probability of a sale. Chapter four investigates the well know price-volume correlation in the housing market. We estimate a Vector Error Correction Model on a rich set of variables. We compare our empirical results against the empirical predictions from a number of housing market theories. Taken together, this dissertation contributes to our understanding of the selling process in the housing market and the factors affecting the liquidity of the housing market.

Erik Robert de Wit received his master's degree in Economics from the VU University Amsterdam. Thereafter he started his PhD in finance at the University of Amsterdam and the Tinbergen Institute. He performed part of his research while attending the National University of Singapore as a visiting researcher. His work has been presented at several major international conferences including the AREUEA, AsRES and ERES conferences. In 2010 Erik won the best paper award at the AsRES annual conference in Taiwan. Erik has taught Finance to first year bachelor students and Investments to third year bachelor students at the University of Amsterdam.

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LIQUIDITY AND PRICE DISCOVERY IN REAL ESTATE ASSETS

Erik de Wit

Amsterdam, 8 september 2011

1. Asymmetric information in the housing market causes time-on-the-market to be a signal of bad quality. The result is that the probability of a sale decreases with time-on-the-market and the probability of withdrawing the house increases with time-on-the-market *(Chapter 2)*

2. The stock-flow matching model of Coles and Smith (1998) correctly predicts that the probability of a sale will drop substantially after the current stock of potential buyers has rejected to buy the house *(Chapter 2)*

3. In housing markets with asymmetric information and where list prices do no have any formal legal role, list prices signal unobserved properties of the house or the seller *(Chapter 3)*

4. Both list price reductions and time-on-the-market reduce transaction prices in the housing market *(Chapter 3)*

5. The probability of a list price reduction increases with time-on-the-market when sellers are uncertain about the value of their house *(Chapter 3)*

6. The price-volume correlation in the Dutch housing market is driven by shocks to the mortgage rate and shocks to sales volume *(Chapter 4)*

7. In low liquidity states of the housing market, house transaction price indices give a distorted view of valuations since many home owners choose not to participate in the market

8. Reducing the transfer tax in the Dutch housing market would permanently improve housing market liquidity, labor market mobility and consequently employment

9. The only reason people get lost in thought is because it is unfamiliar territory.

10. The quality of a dissertation is inversely related to its size.

These propositions are considered defendable and as such have been approved by the promotores Prof. dr. K.G.P. Englund and Prof. dr. M.K. Francke

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FACULTEIT DER ECONOMIE EN BEDRIJFSKUNDE

To my loving wife Lili

Contents

Chapter 1

Introduction

Buying or selling a house is for most households the largest financial transaction they will make in their lives. A house is an illiquid and indivisible asset and its value comprises a substantial part of the household balance sheet[1]. The selling process is characterized by a high level of uncertainty, not only about the final transaction price, but also about the length of time it will take to sell the house, if the house will sell at all. The selling process is further complicated by asymmetric information between the seller and potential buyers about the true quality of the house. Sellers have an incentive to claim their house is of high quality but potential buyers will be wary of the possibility of hidden flaws in the house. Heterogeneity between the set of characteristics of for-sale houses will make potential buyers spend a substantial amount of time on the market before they find a house that best matches their preferences.

This dissertation covers three empirical essays on the housing market. Although we limit ourselves here to the housing market, the findings might be relevant for other sectors of the real estate market or any other market that is characterized by illiquidity, indivisibility of goods and a high level of heterogeneity between goods. Chapter 2 tests two hypotheses bases on empirical predictions from theoretical literature on the selling process in the housing market. We first test whether the empirical predictions from Taylor (1999) - the probability that a house will sell will decline with the time the house has already spent on the market, and the probability that a house will be withdrawn from the market will increase with the time the house has already spent on the market - are true. We also test whether there is a sharp drop in the probability of a sale after the house has spent a sufficient length of time on the market for the current stock of potential buyers to have evaluated the house, as predicted by

[1] In the Netherlands the value of housing comprises 54% of household equity (Van Ewijk and Ter Rele, 2008).

the stock-flow matching model in Coles and Smith (1998). Chapter 3 considers the role of the list price in the housing market. List prices do not have a formal role in the Dutch housing market and many other housing markets. The list price does not act as a ceiling on the transaction price and transaction prices above the list price are observed frequently. List prices would have no role in a housing market with symmetric information between sellers and buyers and the probability of a sale would not be affected by reductions in the list price. Based on this observation we test for the presence of asymmetric information between sellers and buyers in the housing market by testing whether reductions in the list price affect the probability of a sale. Chapter 4 investigates the well know price-volume correlation in the housing market. We estimate a Vector Error Correction Model on a rich set of variables. Apart from a transaction price index and sales volume data, our data includes a list price index and the flow of houses entering the market. We compare our empirical results against the empirical predictions from a number of housing market theories.

1.1 Sales Versus Withdrawals from the Market

Houses typically spend a long time on the market before they are sold. In our dataset from the NVM (Dutch Association of Real Estate Brokers and Real Estate Experts), the average time till sale between 1985 and 2007 was 87 days. Some houses do not sell but are withdrawn from the market before a sale took place. The average time till withdrawal for houses in our dataset that were withrawn from the market before being sold was 200 days. Of particular interest is whether potential buyers view houses which have spend a long time on the market differently from similar houses which have spend a short time on the market. Taylor (1999) develops a model where potential buyers view time on the market as a signal of inferior quality of the house. The implication is that potential buyers' mean valuation of the house declines with the length of time the house has spent on the market. Furthermore, the probability that the house will sell also declines with time on the market. Houses that fail to sell after spending a long time on the market can be withdrawn from the market as the seller prefers to retain the utility the house currently brings him over accepting a bid below his reservation price.

Negative duration dependence in the hazard rate of sale (i.e. the speed of sale) of for-sale houses has been found by e.g. Huang and Palmquist (2001), Pryce and Gibb (2006) and Zuehlke (1987). This negative duration dependence implies that the probability that a for-sale house will be sold declines with time on the market. The current empirical literature on time on the market has not investigated whether there is duration dependence in the hazard rate of withdrawal (i.e. the speed of withdrawal). In chapter 2 we fill this gap in the literature by investigating both time-till sale and time-till withdrawal simultaneously in a competing risks duration model with unobserved heterogeneity with dependence between the hazard rate of sale and the hazard rate of withdrawal. We use the most flexible specification for the duration dependence structure used to date in the time on the market literature. We use a piece-wise constant specification for both the duration dependence in the hazard rate of sale and the hazard rate of withdrawal. This flexible specification enables us to test whether the hazard rates are monotonically increasing or decreasing with time on the market. A monotonically decreasing hazard rate of sale and a monotonically increasing hazard rate of withdrawal would be consistent with the theory in Taylor (1999). Furthermore, we interact the duration dependence term with the calendar time effect as Pryce and Gibb (2006) have shown that the duration dependence structure is not constant over long sample horizons.

The stock-flow matching model from Coles and Smith (1998) also yields empirical predictions for the probability that a for-sale house will be sold. In the model in Coles and Smith (1998), potential buyers spend a significant time on the market searching for a house that best matches their preferences and a for-sale house is first evaluated by the current stock of potential buyers on the market. After the current stock of potential buyers has rejected to buy the house, the house will only be considered by the new flow of potential buyers entering the market. This implies that there should be a sharp drop in the probability of a sale after the current stock of potential buyers has rejected the house since the flow of potential buyers entering the market is only small compared to the current stock of potential buyers on the market. We test this empirical prediction with our duration model by investigating whether the duration dependence terms for the hazard of sale are constant for the first short time on the market period followed by a sharp drop in the value of the duration dependence terms after the initial short time on the market.

1.2 The Role of the List Price

Advertisements of for-sale houses are often accompanied by lots of information about the house being offered for sale. Often pictures of the interior and exterior of the house are included in the advertisement as well as a detailed description of the characteristics of the house and the location and a list price. List prices do not have a formal role in the Netherlands and many other housing markets. The list price does not act as a ceiling to the transaction price and houses can be sold at prices above the list price. A key question therefore is what the role of the list price is in the housing market. The list price might reflect characteristics of the house or the seller which are unobservable to potential buyers. Such characteristics might for example be how motivated (or impatient) the seller is to sell the house. If the housing market would be characterized by symmetric information between buyers and sellers (as in Olsen (1969)) there would be no role for list prices. In such instance both the seller and potential buyers would possess the same information set and a list price would be obsolete. A good test for asymmetric information in the housing market would therefore be to test whether list prices affect outcomes (e.g. time till sale or transaction price) in the housing market. We formulate such a test in chapter 3. We focus on the change in the list price rather than the level of the list price since the level of the list price might be affected by factors which are unobservable to the econometrician.

Our dataset from the NVM includes list price revisions for the years 2005 - 2007. About 20% of sellers lower their list price for their for-sale house during this period and the average list price reduction is 5.5%. We use a timing-of-events duration model as described in Abbring and Van den Berg (2003), where we specify the event to be a list price reduction. We extend the model by allowing for competing risks, where the competing risks are a sale of the house or a withdrawal of the house. We allow for unobserved heterogeneity and dependence between the hazard rate of sale, the hazard rate of withdrawal, and the hazard rate of repricing. Our test for asymmetric information in the housing market consists of testing whether a list price reduction affects the hazard rate of sale and possibly the hazard rate of withdrawal.

Lazear (1986) provides a two-period model in which list prices are actually important. Sellers face uncertainty about buyers' valuations, and learn in the first period. Therefore, second-period list prices are lower than in the first period. The empirical prediction from the model is that list prices decline with time on the market. That is, the longer a house remains on the market, the higher the probability that the list price will be reduced. We test the empirical prediction by testing for positive duration dependence in the hazard of repricing in our timing-of-events duration model.

1.3 The Price-Volume Correlation

Several studies find a positive correlation between price and volume (houses sold) in the owner-occupied housing market. The pattern is found in the US housing market but also in the UK and Sweden. Although this general pattern is confirmed by most studies, the empirical picture is not without ambiguity. For example, Miller and Sklarz (1986) find that the rate of sale in one quarter is positively related to the price change in the next quarter based on condominium data from Hawaii. Stein (1995) on the other hand finds, based on aggregate US data, a significant relation between current sales volume and last year's rate of price change, i.e. a temporal lag in the opposite direction to that found by Miller and Sklarz.

Other papers analyze dynamic econometric models with more structure. Hort (2000) finds no consistent correlation between price changes and turnover changes using panel data for local housing markets in Sweden. Hort goes on to investigate how shocks to fundamentals are transmitted into house prices and sales. Based on a VAR-model she concludes that an interest shock has an immediate negative impact on sales but affects prices only gradually. Andrew and Meen (2003) study aggregate UK data focusing on the adjustment to fundamentals. They find that a shock to fundamentals impact sales and prices in the same direction.

Broadly speaking one can identify three groups of theories to account for the price-volume correlation found in the housing market. The first theory can be described as the credit constraint theory. In the credit constraint theory a favorable shock to housing market fundamentals, such as mortgage rates and unemployment, gives rise to an increase in prices. This appreciation in prices increases homeowners' equity, thereby releasing downpayment constraints. This will have a positive impact on mobility which results in increased transaction volume. This increased transaction volume reflects an improvement in liquidity and this will cause prices to rise even further. Credit constraint theories are described in Stein (1995) and Ortalo-Magné and Rady (1999, 2006). Another set of explanations focuses on the housing market as a search market that fails to clear instantaneously. In the model of Berkovec and Goodman (1996) sellers and buyers are assumed to observe transaction prices but otherwise to be uninformed about underlying market conditions. As a result, a demand increase leads to an immediate increase in transaction volume followed by a gradual increase in reservation and transaction prices. Another explanation from the search market theory for the price-volume correlation has to do with market liquidity. A correlation between price and volume may reflect variations in liquidity and the quality of matching between buyers and sellers. Many sales and more houses on the market should be associated with higher liquidity in the sense of a shorter time to sale and less price uncertainty. This connection has been analyzed by Krainer (2001) and Novy-Marx (2009) in a search market context. A third explanation for the price-volume correlation derives from behavioral considerations. Genesove and Mayer (2001) and Engelhardt (2003) represent seller behavior by prospect theory implying that the marginal disutility of losses exceeds the marginal utility of gains. This phenomenon has been described as loss aversion. If this is the case, sellers should be reluctant to set an asking price below their original purchase price. Genesove and Mayer (2001) and Engelhardt (2003) find empirical support for this hypothesis.

In chapter 4 we document the price-volume correlation for the Dutch housing market. Furthermore, we try to identify the mechanism giving rise to the price-volume correlation using a Vector Error Correction Model. We have variables measuring fundamental developments such as the 5-year fixed mortgage rate and the unemployment level. With respect to market variables, we do not only have transaction price data and sales price data (as other studies do), but we also have list price data and the number of houses put up for sale per month. We compare our results to the credit constraint, search market, and behavioral explanations for the price-volume correlation and establish which of the three theories is consistent with our empirical findings.

Chapter 2

Competing Risks in a Time-on-the-Market Analysis

This chapter is based on De Wit (2010).

ABSTRACT

Theoretical models on the selling process in the housing market are scarce. Taylor (1999) specifies a model where time-on-the-market gives a quality signal of the house to potential buyers if inspection outcomes of the house are not public. We specify a duration model with competing risks, where the competing risks are a sale or a withdrawal from the market. We use a unique administrative dataset from the Netherlands. We find negative duration dependence in the hazard of sale confirming the empirical predictions from Taylor (1999). We also find positive duration dependence in the hazard of withdrawal.

2.1 Introduction

When a home owner puts her house up for sale she will set her reservation price for the asset in such a way that the expected utility of the state of the world wherein she owns the house equates to the expected utility of the state of the world wherein she does not own the house. Not owning the house might mean selling the house and moving to another city with better job prospects. Not owning can also mean moving to another type of house or neighborhood which better matches her current needs. Not owning might also mean accepting a price for the house above the present value of a stream of future rental income. The key point is that a home owner will only participate in trade if it increases her expected utility.

Home owners who have put their house up for sale might withdraw their house from the market if the alternative state of the world to owning the house has ceased to exist (e.g. the job offer in the other city has been withdrawn or the groom ran away from the alter). Such events can reasonably be assumed to be exogenous to the selling process of the house. In fact, if the housing market were a perfectly competitive market (as in e.g. Olsen 1969), such events would be the only cause for a home owner to withdraw a house from the market. However, housing markets are characterized by asymmetric information between the seller and potential buyers (and even among potential buyers).

Taylor (1999) formulates a theoretical model in which buyers herd if the outcome of quality inspections of the house are not observed to potential buyers. The result is that the mean valuation of a house from potential buyers decreases the longer the house has been for sale on the market. At some point home owners are more likely to prefer a withdrawal of their house from the market and retain the utility their house currently brings them over seeing their house becoming even more stigmatized. Keeping the house for sale on the market any longer would result in the mean valuation from potential buyers falling even further below her reservation price the longer the house remains on the market.

Thus, the theory describes a positive relation between the time a house has been for sale on the market and the rate at which home owners withdraw their house from the market. This paper tests this hypothesis empirically. We find a strong relation between time on the market and the rate at which houses are withdrawn from the market. For example, the rate at which houses are withdrawn from the market is 168% higher between 181 and 270 days on the market compared to the first 30 days on the market.

We use a mixed proportional hazard model with competing risks. The empirical model builds on Heckman and Honoré (1989). The competing risks are an exit of the house from the market through either a sale or a withdrawal from the market. We use a piecewise constant specification for the duration dependence in the transition rates from market to sale and market to withdrawal. Moreover, we allow the duration dependence to be time-varying over the sample horizon.

We use a unique administrative data set from the NVM (Dutch Association of Real Estate Brokers and Real Estate Experts) on 1,820,022 houses put up for sale on the Dutch housing market during the period 1985–2007. 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 observe whether a house has been sold or withdrawn from the market by the seller. Furthermore, we observe a very extensive set of characteristics of each house.

The remainder of the paper is organized as follows. Section 2.2 describes the institutional setting of the Dutch market for owner occupied homes. Section 2.3 describes our empirical model that is inspired by the theoretical literature. Section 2.4 describes the unique administrative data set. Section 2.5 presents the estimation results and some sensitivity analyses. Section 2.6 concludes.

2.2 Institutional Setting of the Dutch Housing Market

In this section we describe some institutional aspects of the Dutch housing market, whereby we focus on the owner occupied sector. It is not our intention to give an exhaustive description of the Dutch housing market. Instead, we explain the basic structure and highlight aspects that are relevant for our purposes. We rely on figures from Statistics Netherlands. The Netherlands had about 16 million inhabitants in 7 million households in 2006. Of these 7 million households, 56% live in an owner occupied house and the remaining part rent their house. The average sales price of existing owner occupied homes was 235,842 euro in 2006, which is 4.57 times the average income per household.

The Dutch housing market experienced a large real price increase during the 1990's. This price increase can be explained by several other factors apart from growth in real income. First, the Netherlands has an increasing population and one of the highest population densities in the world. Stringent spatial planning policy and very long planning procedures governing new residential construction make it more and more difficult to increase the housing supply. So, the increasing population will put upward pressure on house prices. Swank, Kakes and Tieman (2002), and Vermeulen and Rouwendal (2007) show that the Netherlands has an enormously low price elasticity of supply. Second, there were major changes in the Dutch mortgage finance market during the 1990's. Since 1990 banks can give a mortgage based on two salaries, taking the salary of the spouse into account (before 1990 banks could only give mortgages based on one salary). This has increased the budget for house buyers. Another major change was the enormous financial innovation in the mortgage market. New mortgage products were introduced during the 1990's such as the investment mortgage, which made it more affordable for many people to purchase a house. This all happened in an environment of falling mortgage rates (e.g. the 5-year fixed mortgage rate fell from 9.3% in January 1990 to 3.8% in January 2006) and stable inflation of about 2% per year.

The Dutch owner occupied housing market is highly subsidized through the mortgage finance market. Home owners can subtract the interest costs on their mortgage from their taxable income at the marginal income tax rate. This leads to a reduction in interest costs of 32-52%. Home owners do have to pay an imputed rent tax but this tax is very small. The tax savings make owning a house very popular among mid to high income citizens in the Netherlands. In a survey OTB (2003), over 90% of respondents indicated they preferred purchasing a house over renting if they could afford to purchase a house. Housing is now the largest asset class on the household balance sheet with 54% of total household assets, pension assets come second with 44% of total assets. These numbers were respectively, 43% for housing and 28% for pensions in 1980. Van Ewijk and ter Rele (2008) mention that this trend has made Dutch households more vulnerable to shocks in national and international housing markets and financial markets.

The Netherlands has one of the most highly developed mortgage markets in Europe. Financial institutions offer a wide variety of mortgages. The Gedragscode Hypothecaire Financieringen (code of conduct for mortgage finance) describes among other things the maximum loan-to-income ratios mortgagees can obtain. For most Dutch citizen, 4.5 times the income is the maximum they can borrow but this also depends on interest rates and banks can provide higher loans in exceptional cases. The code of conduct does not give guidelines on the maximal loan-to-value ratio. The average loan-to-value ratio for first-time buyers in 2007 was 114% (Ball (2009)). Of owner-occupiers, 89% have a mortgage. House owners can insure their mortage against default through a national insurance scheme known as Nationale Hypotheek Garantie (NHG). This insurance will cost the borrower 30 basis points of the principal of their loan but will give them a 20-30 basis point reduction on their interest rate. In case the borrower defaults the NHG scheme will pay the debt service to the bank and the NHG will try to recoup the principal and interest from the borrower if possible.

There are substantial transaction costs involved in purchasing a house in the Netherlands. The total transaction costs on the purchase of an existing home is approximately 10%. The cost components are transaction tax (6% of sales price), broker costs (1-3% of sales price), mortgage initiation fees (1-1.5% of mortgage principal), notary fees and possibly intermediary fees. These transaction costs are typically financed by including them in the mortgage principal. Stamp duty does not have to be paid on new houses but a 19% VAT applies.

The seller of the house usually uses the services of a real estate broker. About 70% of all houses offered for sale are offered through a member of the NVM. The real estate broker will advise the seller on a suitable list price, but it is the seller who will decide on the list price. The real estate broker will advertise the house in media such as local newspapers and more recently the internet. Advertisements normally contain the list price, pictures of the house, and a description on the characteristics. Over the last ten years the internet has become an important medium for advertising houses offered for sale. The real estate broker only receives a fee if the house is actually sold and the fee is usually 1-3% of the transaction price. Interested potential buyers will contact the broker for information requests and to schedule visits. The broker will usually host a visit to the house and the seller will not be present.

List prices do not have a formal role in the Netherlands since they are not binding. A seller can try to refuse a list price or try to negotiate a higher price even if a potential buyer is willing to pay the list price. There are rules to the negotiation process between buyer and seller. A potential buyer will communicate his bid to the broker. The broker will inform the seller of the bid and this starts the negotiation process. Negotiation with several buyers at the same time or revealing bids to other buyers is not allowed. The order in which the seller should negotiate with potential buyers is based on the order in which the potential buyers make their first bid. The seller has by law an obligation to reveal all relevant information about the house. The buyer can hold the seller liable if he discovers a hidden defect to the house which had originated before the purchase date. The buyer would of course have to proof that the defect actually originated before the purchase in case the seller claims otherwise.

The rental market in the Netherlands consists of roughly 44% of the total market; roughly 90% of which is regulated. The rental market is strongly regulated through a system that prescribes both the rent level and the maximum annual rent increase. Furthermore, the dominant position of housing associations (jointly owning 75% of the total rental stock) has large implication on the rental sector. In general, housing associations set rents well below the maximum level allowed for by law, thus further increasing benefits to rental households. Partly because of the dominant position of housing associations the private rental sector is almost non-existent in the Netherlands.

The mentioned subsidization schemes influence tenure choice in the Netherlands. Conijn and Schilder (2009) show that there is a strong positive relationship between the probability of a household being owners and the income of the household. Of all renters, 31% receive rent subsidy. Rent subsidy is available for low income households, so renting is more attractive for low income households. Moreover, access to most housing of housing associations is restricted to income, higher income groups being unable to obtain such housing. On the other hand, since the Netherlands has a progressive income tax scale and mortgage interest costs are 100% deductible, owning becomes progressively more attractive the higher the income of the household. Koning, Saitua and Ebregt (2006) and Romijn and Besseling (2008) estimate the total amount of subsidies in both sectors (including tax deductibility, rent subsidy and implicit subsidies following rent regulation) to be approximately balanced for owner-occupier and renter households; the total amount of subsidization is roughly 14.25 billion euro annually in the owner-occupied sector and approximately 14.5 billion euro annually in the rental sector.

2.3 The Model

2.3.1 Theoretical Framework

If the housing market were a perfectly competitive market (as in e.g. Olsen 1969) with symmetric information, only exogenous events would cause withdrawals of houses from the market. Caplin and Leahy (1996) discuss the importance of trading costs, price, and volume in assets markets with frictions. The authors focus among other things on the importance of self-selection effects in which the volume of trade reveals information not only on those who actually complete trades, but also on those who choose not to trade. Here low volume means that many agents posses information that has convinced them that trade is not profitable. The implication of this is that withdrawals of houses from the market might not be exogenous events.

Taylor (1999) analyses time-on-the-market as a sign of quality in a two-period model with two-sided asymmetric information and learning by potential buyers. The analysis focus on how potential buyers view time-on-the-market as a quality signal of the house. A potential buyer who discovers a house which has been for sale for a long time will naturally be suspicious about the reason the house did not sell earlier. Three possible reasons are presented, i) she may be the first potential buyer to discover the house, ii) the house may have been overpriced given the preferences of earlier potential buyers, or iii) earlier potential buyers might have detected a flaw in the house which is not apparent to her. The weight the potential buyer assigns to either possibility i or ii being the case will decline with time-on-the-market as the number of potential buyers who will consider the house increases with time. This means the weight assigned to possibility iii increases with time-on-the-market. The result is that the expected sale price and probability of a sale will decline with time-on-the-market if quality inspections are not made public. This herding and informational cascade effect will not occur if inspections are public and reservation price histories are observable. Herding creates two opposing incentives for the seller if historical reservation prices are observable (and inspections unobservable). First, relatively lower expected sale prices at longer market times gives the seller an incentive to set a lower initial reservation price in order to sell at a shorter market time with a higher sale probability (the option-value effect). Second, the seller has an incentive to set a high initial reservation price so that potential buyers who discover the house after a longer market time will believe that failure to sell at a shorter market time was due to a lack of a serious buyer rather than detection of low quality (the signal-dampening effect). The herding effect will be increased if the reservation price history is not observable. In this setting there still is an option-value effect but no signal-dampening effect. The model is specified with high and low quality houses where low quality sellers will mimic the reservation prices of high quality sellers. In this setting sellers cannot use the reservation price as a signal of quality. Houses that remain on the market for a long time become stigmatized, and can eventually be removed from the market as sale becomes unlikely. Empirical evidence confirms that the probability of a sale decreases with time-on-the-market (e.g. Anglin, Rutherford and Springer, 2003; Huang and Palmquist, 2001; Pryce and Gibb, 2006; and Zuehlke, 1987).

It must be noted that withdrawing the house from the market is not exogenous to selling it. The price a seller pays for keeping a house on the market too long is that both the probability of a sale and the potential buyer's mean valuation of the house will decline further the longer the house remains on the market. At some point home owners are more likely to prefer a withdrawal of their house from the market and retain the utility their house currently brings them over seeing their house becoming even more stigmatized[1]. Sellers of stigmatized houses with hidden flaws are more likely to reduce their reservation price while sellers of stigmatized houses without hidden flaws are more likely to withdraw. This also implies that the probability of a withdrawal should increase with time-on-the-market. Empirical analysis should therefore take withdrawals into account and consider that withdrawals might not be exogenous.

Coles and Smith (1998) develop a marketplace model. In this model there may not currently be a buyer who matches with the seller of a house. The seller will therefore have to wait till an appropriate buyer enters the market. This model differs from the search literature where a buyer-seller match exists but the agent has to pay search costs to find his match. In the marketplace model, when the seller puts up his house for sale his offer will first be evaluated by the stock of all potential buyers on the market. Once the current stock of buyers has rejected his offer he can only be matched by the new flow of buyers entering the market. If buyers spend a significant amount of time on the market then the flow of new buyers will naturally be much smaller then the stock of buyers. Hence, there should be a sudden drop in the probability of sale after the seller's offering has been rejected by the current stock of buyers.

The key conclusion is that the probability of sale will decline with time-on-the-market and the probability of withdrawal will increase with time-on-the-market if quality inspections are not public (Taylor, 1999). It is important to distinguish between information known to the market and to the econometrician. For example, reductions in reservation prices might be observed by both buyers and sellers but not by the econometrician. Furthermore, there should be a sudden drop in the probability of sale after a house has spend a sufficient time on the market for the current stock of potential buyers to have evaluated the offering (Coles and Smith, 1998).

2.3.2 Empirical Model

The main conclusion from the theoretical literature is that withdrawals from the market are not exogenous to the selling process (e.g. Caplin and Leahy, 1996; and Taylor, 1999). In particular, Taylor (1999) shows that both the probability of a sale and the expected sale price decreases with time-on-the-market if the result of quality inspections are not public information. This implies that the probability of a withdrawal will increase with time-on-the-market as owners of stigmatized houses will prefer a withdrawal at some point over accepting a bid below the reservation price or seeing the stigma becoming even worse. The key empirical problem is that withdrawals are not exogenous to sales. The cause of the endogeneity is that the speed at which houses are sold and the speed at which houses are withdrawn from the market are simultaneously determined since they both depend on the characteristics of the house and

[1]Note that the seller can withdraw the house from the market and put it up for sale again after some time if a first sale attempt failed. The stigma will be eliminated if the new group of potential buyers do not know about the past failed sale attempt. However, even if the new group of potential buyers is aware of the previous withdrawal they do not know with certainty whether the withdrawal was due to a stigma effect or exogenous factors.

the seller. Therefore, we model the probability of sale and probability of withdrawal as endogenous variables. We use a competing risks model with duration dependence to estimate the causal effect of time-on-the-market on the probability of sale and the probability of withdrawal (Heckman and Honoré (1989)).

There might be information observed to market participants but not to the econometrician. For example, reservation prices are not observed by potential buyers but reductions in reservation prices might be signalled to potential buyers through list price reductions (see e.g. de Wit and van der Klaauw, 2010). We have the initial list price in our data set but not any possible reductions in the list price. The implication of this is that we will underestimate the stigma effect since we cannot control for any possible list price reductions. That is, the true decline in the probability of sale with time-on-the-market will be more severe than we estimate. Analogously, the true increase in the probability of withdrawal will be higher than we estimate.

Consider a house which is put on the market at (calender) date τ_0. Our model is a continuous time duration model in which t denotes the time a house is already on the market. 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.

We denote the unobserved heterogeneity 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 and, v_s, the rate at which a house is sold after t periods on the market follows a familiar mixed proportional hazard specification

$$\theta_s(t|x, \tau_0, v_s) = \lambda_s(t)\psi_s(\tau_0 + t)\exp(x'\beta_s + v_s)$$

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

$$\theta_w(t|x, \tau_0, v_w) = \lambda_w(t)\psi_w(\tau_0 + t)\exp(x'\beta_w + v_w)$$

In this 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 and are our key functions of interest. We use very flexible specifications for the duration dependence functions. We take $\lambda_s(t)$ and $\lambda_w(t)$ to have a piecewise constant specification,

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

where j is a subscript for duration intervals, and $I_j(t)$ are time-varying dummy variables that are one in consecutive time intervals. A large number of intervals would allow any duration dependence pattern to be approximated arbitrarily closely. We normalize the pattern of duration dependence by fixing $\lambda_{i1} = 0$. Note that the duration dependence effect is controlled for calendar time effects (e.g. Pryce and Gibb, 2006). This is especially important in our case since our database covers such a long time period. It should be noted that in a housing market with symmetric information, time on the market does not provide a signal to the market and the duration dependence terms should be constant. Our test for the absence of a herding effect thus consists of testing if $\lambda_s(t) \geq \lambda_s(t-h)$ and $\lambda_w(t) \leq \lambda_w(t-h)$, where $h \in (0, t]$. There might be a sudden sharp drop in the probability of sale after the house has spend a sufficient amount of time on the market for the current stock of potential buyers to have evaluated the offered house in line with the marketplace model (Coles and Smith, 1998). However, the duration dependence terms should be constant after that initial drop if there is symmetric information in the housing market.

Let t_s be the realized duration when a house is sold. The conditional density function of $t_s|x, \tau_0, v_s, v_w$ can be written as

$$f_s(t_s|x, \tau_0, v_s, v_w) = \theta_s(t_s|x, \tau_0, v_s) \exp(-\int_0^{t_s} \theta_s(z|x, \tau_0, v_s) + \theta_s(z|x, \tau_0, v_w)dz)$$

And similarly the conditional density function of the time until leaving the market $t_l|x, \tau_0, v_s, v_w$ equals

$$f_w(t_w|x, \tau_0, v_s, v_w) = \theta_s(t_w|x, \tau_0, v_w) \exp(-\int_0^{t_w} \theta_s(z|x, \tau_0, v_s) + \theta_s(z|x, \tau_0, v_w)dz)$$

Let $G(v_s, v_w)$ be the joint distribution function of the unobserved characteristics (v_s, v_w). The joint density function of (t_s, t_w) conditional on x equals

$$f_{s,w}(t_s, t_w|x, \tau_0) = \int_{v_s} \int_0^{v_w} f_s(t_s|x, \tau_0, v_s) f_w(t_w|x, \tau_0, v_w) dG(v_s, v_w)$$

We use a very flexible specification for the joint distribution function of the unobserved characteristics $G(v_s, v_w)$ (e.g. Heckman and Singer, 1984). We take the joint distribution of the unobserved heterogeneity terms v_s and v_w to be trivariate discrete with unrestricted mass-point locations for each term. Specifically, we allow for $K = 3$ terms

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

with $p_1 + \ldots + p_K = 1$. Dependence between the different unobservable heterogeneity terms is allowed in this specification for $K \geq 2$. The degree of flexibility increases for larger values of K. We normalize the model by not including an intercept in the vector of observed characteristics x instead of restricting the locations of the mass points.

It is straightforward to derive the likelihood contributions from the specifications of the different hazard rates. We do not have any initial conditions problems since we use a flow sample of houses entering the market. The right-censoring in the data is exogenous, 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. If $i = 1, \ldots, n$ denote the observations, then the loglikelihood function equals

$$\log \ell = \sum_{i=1}^{n} \log \left\{ \int_{v_s} \int_{v_w} \theta_s(t_i|x_i, \tau_{0,i}, v_s)^{c_{s,i}} \theta_w(t_i|x_i, \tau_{0,i}, v_w)^{c_{w,i}} \right.$$
$$\exp\left(- \int_0^{t_i} \theta_s(z|x_i, \tau_{0,i}, v_s) + \theta_w(z|x_i, \tau_{0,i}, v_w) dz \right)$$
$$\left. dG(v_s, v_w) \right\}$$

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.

We perform a number of sensitivity analyses. First, we estimate the model with independent hazard rates of sale and withdrawal. Second, we include the Haurin (1988) atypicallity measure in the set of observed characteristics to see if this changes the duration dependence. Third, we exclude ten percent of the most atypical houses measured along the Haurin (1988) atypicallity measure to see if the results are caused by atypical houses. Last, we want to measure the direct effect of time-on-the-market on the transaction price. We model the transaction price and the hazard of sale and withdrawal simultaneously since time-on-the-market and the transaction price are endogenous. We use a hazard rate model for the transaction prices p, with the density function

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

with

$$\theta_t(p|t, \tau_0, x, v_t) = \lambda_t(p)\psi_t(\tau_0 + t) \exp\left(x'\beta_t + \delta_t \cdot t + v_t\right)$$

where $\psi_t(\tau_0 + t)$ denotes calendar-time effects at the moment of selling the house, and t is the time the house was on the market before being sold. The unobserved heterogeneity term v_t can be correlated to the unobserved heterogeneity terms in the selling and withdrawing hazard to account for endogeneity. The parameter of interest is the direct effect of δ_t capturing the effect of time on the market on the transaction price. In using hazard rates models for transaction prices we follow Donald, Green and Paarsch (2000) who implement a hazard-based estimator of wage, earnings, and income densities in the presence of covariates. The results of these sensitivity analyses will be discussed in subsection 2.5.2.

Table 2.1: *Some Characteristics of the Data Set*

Number of observations	1,820,022
Number of sales	1,567,591
Number of withdrawals	174,004
Number of right-censored	78,427
Average list price	€200,802
Average selling price	€179,474
Average time-till-sale	87 days
Average time-till-withdrawal	200 days

Note.–The sample covers 1985-2007. Time on the market is right-censored for houses which were still on the market on January 1, 2008.

2.4 The Data

Our data contains all houses and apartments offered for sale through all real estate brokers associated to the Dutch NVM (Dutch Association of Real Estate Brokers and Real Estate Experts) between January 1985 and December 2007. The Dutch NVM has a market share in the Dutch brokerage market for owner occupied homes of about 70%.

For each dwelling 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 dwelling was sold or was taken off the market. About 10% of all houses put up for sale are withdrawn from the market. If it was still on the market on January 1, 2008, the time on the market is exogenously right censored.

For each dwelling, we observe a rich set of characteristics. There is information on the type of dwelling (12 types), the construction period (5 periods), parking facility (4 types), garden location (9 types), and region (76 regions).[2] The data also include several size characteristics such as the floorsize, lotsize (in square meters), and the number of rooms in the dwelling. Furthermore, we observe whether the dwelling is well isolated, type of heating system (3 types), location next to a quiet road, possible groundlease, presence of an elevator in the apartment building, and two variables measuring inside and outside quality on a discrete scale from 1 to 9. These quality measures are determined by the real estate broker selling the dwelling.

Table 2.1 presents some details of the data. Further characteristics of the data are provided in appendix 2.9. In total our data contain 1,820,022 dwellings put on the market. For 1,567,591 dwellings we observe a sale, 174,004 dwellings were taken

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

off the market, and 78,427 dwellings were still on the market at the end of the observation period. On average, the initial list price is €200,802 (although the average initial list price for houses which did sell was substantially lower at €188,559), and the average selling price is €179,474. About 86% of the houses are sold below the list price.[3]

Figure 2.1 shows the Kaplan-Meier estimates for the survival function for selling

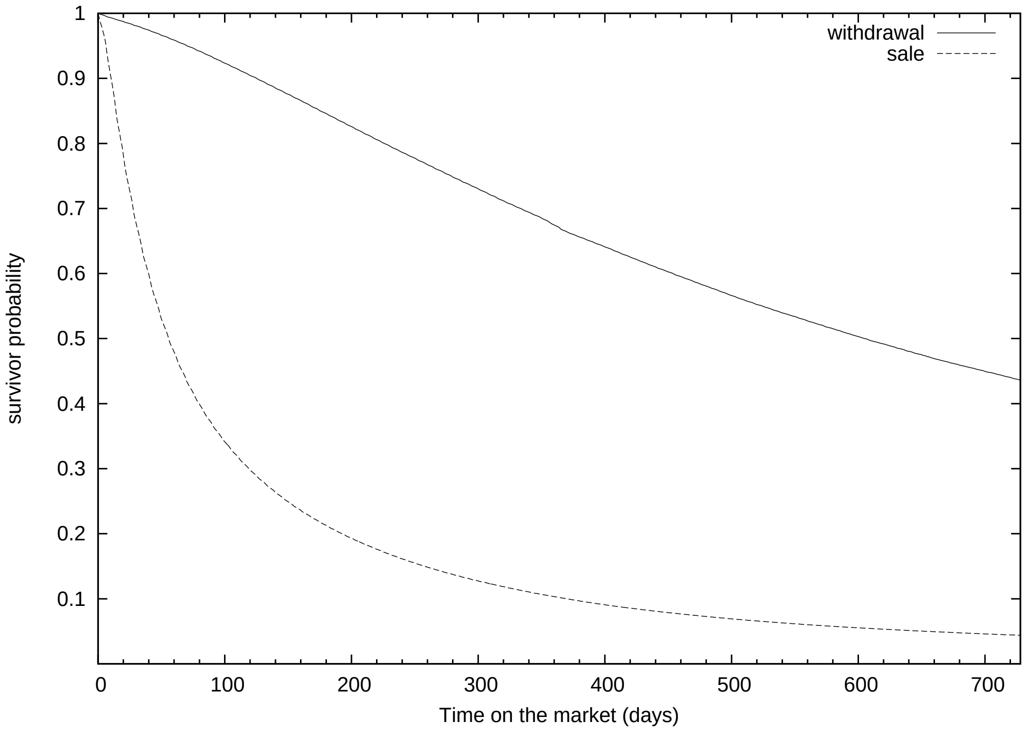

Figure 2.1: *Kaplan-Meier estimates for the survivor function to selling the house and withdrawal.*

the house and withdrawing from the market (without sale). The survivor function is the probability that a house will stay on the market up till time t (see e.g. Lancaster (1990). When estimating the survivor function for selling the market, withdrawing

[3]The list price premium is the difference between the log of the initial list price of the dwelling 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 loglinear regressions separately performed for each year (e.g. Rosen, 1974). The R-squared for these regressions are on average 79.1% and range between between 77.0% and 80.9%. This approach is identical to that in Merlo and Ortalo-Magné (2004). The variable gives us a measure of overpricing or underpricing of the dwelling based on what would be a "normal" list price for the dwelling based on observed characteristics. The estimated coefficients for the year 2007 are presented in appendix 2.7.

is considered to be exogenous, 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 is sold after 56 days. Withdrawal is a much slower process, it takes 619 days before the probability of withdrawn reached 0.5.

2.5 Estimation Results

2.5.1 Parameter Estimates

We discuss the results of our empirical analyses in this section. The parameter estimates of the baseline model will be discussed first. The next subsection will discuss the results of the 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. We have three mass points ($K = 3$) for the unobserved heterogeneity. The vector of observed characteristics includes 141 variables.

The parameter estimates of our baseline model are presented in table 2.2. Further parameter estimates of the baseline model are presented in appendix 2.10. The main parameters of interest are the $\lambda's$, which represent the duration dependence in the hazard of sale and the hazard of withdrawal. These parameter estimates are also presented in figure 2.2 with their 95 percent confidence bounds.

Note that the hazard rate in the 31-60 day interval is only slightly different (2.3% higher) from to the 0-30 day interval. After 60 days the hazard rate of sale starts to decline as a function of time on the market. This gradual monotonic decline is consistent with a housing market characterized by asymmetric information where buyers perceive time-on-the-market as a quality signal as in Taylor (1999). The hazard rate of sale is $(\exp(-0.175) - 1) \times 100\% = -16\%$ lower in the 61-120 day interval compared to the 0-30 day interval. The rather constant hazard rate of sale in the first 60 days combined with the sharp decrease after 60 days is in line with the stock-flow interpretation of Coles and Smith (1998). The current stock of buyers has rejected the house in the first 60 days after which the seller can only match the house with the flow of new buyers entering the market. The stigmatization effect seems to be quite substantial, for example, in the 361-720 day interval the hazard rate of sale is $(\exp(-0.574) - 1) \times 100\% = -44\%$ lower compared to the 0-30 day interval.

There is also substantial duration dependence in the hazard rate of withdrawal. The hazard rate of withdrawal is monotonically increasing with time-on-the-market. This paper is the first showing empirical evidence in favor of positive duration dependence in the rate of withdrawal. The result is consistent with stigmatized sellers deciding to withdraw their house from the market after spending a long time-on-the-market. The seller prefers a withdrawal over accepting a bid below his reservation price or keeping the house on the market and seeing the probability of sale decline even further with time.

The list-price premium has been included in the set of explanatory variables. The list-price premium is defined as the list-price of the house compared to a hedonic estimate for the list price of the house. A positive list-price premium thus implies that the house is priced high compared to similar houses in the market. We will not give a strong causal interpretation to the covariate effect of the list-price premium on time-on-the-market since some unobservables such as the thinness of a submarket (see e.g. Lazear, 1986) can also affect the list-price premium. However, the estimation results are consistent with Lazear (1986) and theories that state that the list price is positively related to the reservation price (e.g. Albrecht, Gautier and Vroman, 2009). Houses with a higher list price premium have a lower probability of sale.

The unobserved heterogeneity distribution shows three mass points. Most probability mass (58%) is located at houses which have a low rate of sale and a low rate of withdrawal. These might for example be sellers who plan to move to a bigger house in the same area and have not purchased a new house yet. They can afford a long time-on-the-market due to a lack of time pressure. The second mass point (39% probability mass) describes houses which have both a high rate of sale and withdrawal. The third mass point (4% probability mass) describes houses with a high rate of sale and low rate of withdrawal. These might be houses of which the seller has already bought a new house which causes the seller to set a lower reservation price. The main conclusion is that there are relevant unobserved characteristics which causes dependency between the two hazards.

Table 2.2: *Estimation Results of the Baseline Model*

	Sale Hazard θ_s		Exit Hazard θ_w	
Duration dependence				
λ_0 (0-30 days)	0		0	
λ_1 (31-60 days)	0.023	(0.007)	0.127	(0.030)
λ_2 (61-120 days)	-0.175	(0.008)	0.449	(0.029)
λ_3 (121-180 days)	-0.347	(0.011)	0.651	(0.035)
λ_4 (181-270 days)	-0.419	(0.013)	0.874	(0.039)
λ_5 (271-360 days)	-0.471	(0.018)	1.034	(0.048)
λ_6 (361-720 days)	-0.574	(0.021)	1.290	(0.057)
λ_7 (> 720 days)	-0.720	(0.045)	...	
List price premium	-0.694	(0.014)	0.005	(0.043)
Unobserved heterogeneity				
υ_1	-6.151	(0.398)	-8.314	(1.057)
υ_2	-4.804	(0.394)	-7.078	(1.055)
υ_3	-4.740	(0.395)	-8.706	(1.054)
p_1	0.577	(0.044)		
p_2	0.387	(0.045)		
p_3	0.036	(0.004)		
Additional controls	Yes		Yes	
Log likelihood	-10,084,610.67			
Observations	1,820,022			

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(lotsize), log(lotsize) squared, log(floorsize), log(floorsize) 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, groundlease, inside and outside quality of the house, and regions. Standard errors are in parentheses.

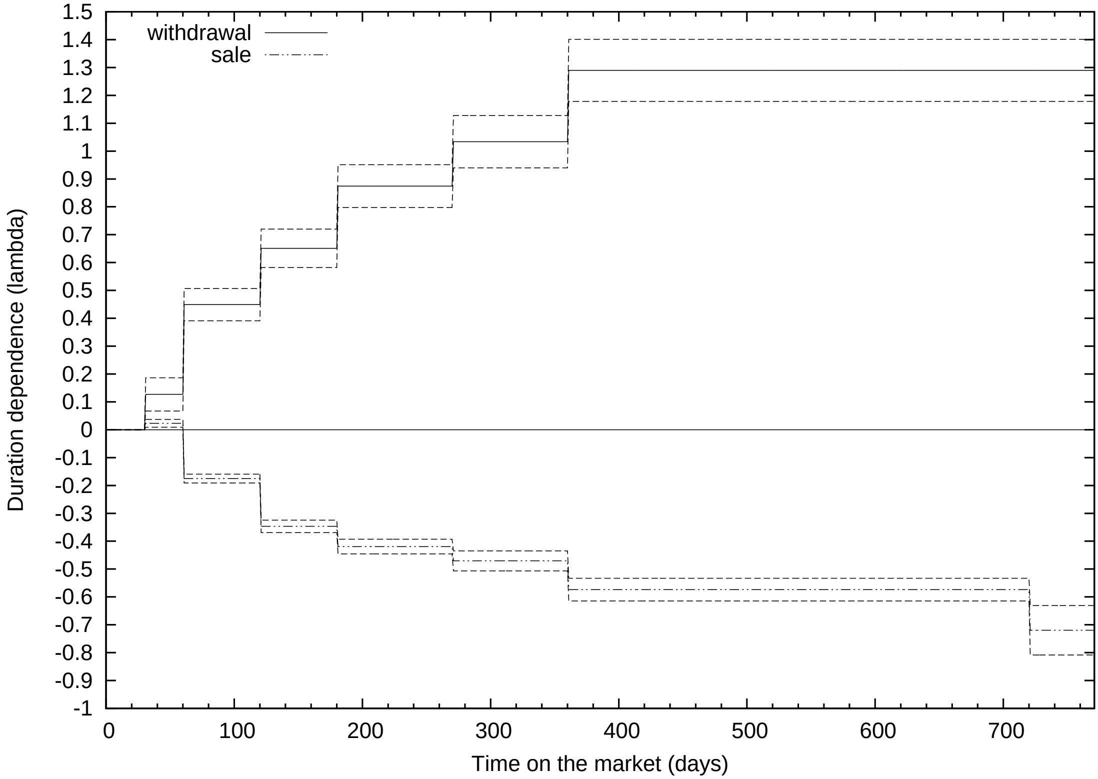

Figure 2.2: *The parameters $\lambda_{s,0}$ and $\lambda_{s,0}$ for the first duration interval are normalized to zero. The duration dependence is of the transition rate from market to sale and from market to withdrawal. The figure also presents the 95 percent confidence bounds.*

2.5.2 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 duration dependence in the hazard rates of sale and withdrawal.

The first sensitivity analysis considers the effects on the parameter estimates of the model when the hazard rates of sale and withdrawal are falsely assumed to be independent of each other. Independence implies that the unobserved heterogeneity components v_s and v_w are independent. From the top plane in Table 2.3 it can be seen that not allowing for dependency between the hazard rates changes the estimated effects of the duration dependence. The hazard of sale is slightly higher in the first 270 days on the market and lower after that compared to the baseline model. Furthermore, the hazard of withdrawal is higher in all intervals compared to the baseline model, especially the later intervals. The implication is that not allowing for dependence between the hazard rates overstates the stigma effect.

The second sensitivity analysis considers the effect of atypical houses on our results. Haurin (1988) considers how atypical a house is compared to the houses in its region. Summary statistics of the Haurin atypicallity variable are given in appendix 2.8. First, including the Haurin (1998) atypicallity measure in our set of independent variables does not alter the parameter estimates of the duration dependence terms. Second, we re-estimate the baseline model after removing 10% of the most atypical houses from the data. From the second plane in Table 2.3 it can be seen that this only slightly alters the parameter estimates. The implication is that the duration dependence is not driven by atypical houses but also exists in the market for regular houses.

In the last sensitivity analysis, we measure the effect of time-on-the-market on the transaction price as described in subsection 2.3.2. The lower panel of table presents the results. Note that jointly modelling the transaction price with the sale and withdrawal hazards hardly changes the duration dependence structure for the sale and withdrawal hazards. At the bottom of table 2.3 it can be seen that the estimated coefficient for time-on-the-market is positive. This means that the transaction price is decreasing with time-on-the-market. It is important here to distinguish between the information known to the market and the information known to the econometrician. Our database does not include data on changes in reservation prices during the time the house is on the market. Although the reservation price itself will be unobserved to buyers in a housing market with asymmetric information, changes in the reservation price might be signalled to the market by reductions of the list price (e.g. de Wit and van der Klaauw, 2010). The relation between time-on-the-market and lower transaction prices might therefore be caused by the direct effect of a reduction in the reservation price after the house has been on the market for some time. The main conclusion is that the duration dependence structure in the hazards of sale and withdrawal are hardly changed by jointly modelling the sale and withdrawal hazards with the transaction price.

Table 2.3: *Sensitivity analyses of the duration dependence.*

	Sale Hazard θ_s		Exit Hazard θ_w		Transaction price	
Independent hazards						
λ_0 (0-30 days)	0		0			
λ_1 (31-60 days)	0.025	(0.007)	0.128	(0.030)		
λ_2 (61-120 days)	-0.172	(0.008)	0.460	(0.030)		
λ_3 (121-180 days)	-0.341	(0.011)	0.698	(0.037)		
λ_4 (181-270 days)	-0.416	(0.014)	0.986	(0.044)		
λ_5 (271-360 days)	-0.472	(0.018)	1.227	(0.057)		
λ_6 (361-720 days)	-0.597	(0.020)	1.705	(0.076)		
λ_7 (> 720 days)	-0.832	(0.044)				
Model excluding atypical houses						
λ_0 (0-30 days)	0		0			
λ_1 (31-60 days)	0.020	(0.007)	0.142	(0.032)		
λ_2 (61-120 days)	-0.175	(0.008)	0.475	(0.031)		
λ_3 (121-180 days)	-0.351	(0.012)	0.685	(0.037)		
λ_4 (181-270 days)	-0.428	(0.015)	0.930	(0.042)		
λ_5 (271-360 days)	-0.470	(0.020)	1.117	(0.051)		
λ_6 (361-720 days)	-0.615	(0.023)	1.402	(0.060)		
λ_7 (> 720 days)	-0.764	(0.049)	...			
Model with transaction price						
λ_0 (0-30 days)	0		0			
λ_1 (31-60 days)	0.023	(0.007)	0.123	(0.030)		
λ_2 (61-120 days)	-0.175	(0.008)	0.445	(0.028)		
λ_3 (121-180 days)	-0.346	(0.011)	0.639	(0.032)		
λ_4 (181-270 days)	-0.418	(0.013)	0.848	(0.033)		
λ_5 (271-360 days)	-0.469	(0.017)	0.993	(0.039)		
λ_6 (361-720 days)	-0.576	(0.019)	1.220	(0.043)		
λ_7 (> 720 days)	-0.733	(0.044)				
Days on the market δ					0.003	(0.00006)

Note.– Similar specification and controls as in the baseline model. The estimated coefficients and standard errors of the model with the atypicallity variable are the same as the baseline model and are therefore not included in the table. Standard errors are in parentheses. Full sets of parameter estimates are available on request.

2.6 Conclusions

Theoretical models for the sale process in the housing market are scarce. In this paper we test the empirical prediction from Taylor (1999) that the probability of selling a house decreases with the time the house has been for sale on the market. Furthermore, withdrawals from the market are not exogenous to sales (see e.g. Caplin and Leahy (1996)). Therefore, we model the hazard rate of sale and the hazard rate of withdrawal simultaneously. Taylor states that houses can become stigmatized after they have remained on the market for a long time. Owners of stigmatized houses might prefer a withdrawal of their house from the market over seeing their house becoming even more stigmatized. Thus, the probability of withdrawal can be expected to be increasing with time-on-the market.

We specified a duration model with competing risks (a sale or withdrawal from the market) and unobserved heterogeneity. We find positive duration dependence in the hazard of sale, meaning that the probability of a sale decreases with time-on-the-market. Furthermore, we also find that the probability of withdrawal increases with time-on-the-market. This is the first paper finding evidence for positive duration dependence in the hazard of withdrawal. Consistent with the stock-flow matching model in Coles and Smith (1998), we also find the hazard of sale to be constant for a short period followed by a sharp drop.

2.7 Appendix: Hedonic Regression

Table 2.4: *List Price Hedonic Regression for 2007 (I)*

Constant	7.752	(0.013)
Seize Characteristics		
Number of Rooms	0.011	(0.001)
Log(lotsize)	-0.046	(0.001)
Log(lotsize)^2	0.010	(0.000)
Log(floorsize)	0.002	(0.030)
Log(floorsize)^2	0.087	(0.003)
Construction Period (1991-2000 is base)		
Before 1905	0.012	(0.027)
1906-1944	-0.038	(0.002)
1945-1990	-0.116	(0.001)
After 2001	0.001	(0.002)
Type of House (Terraced House is base)		
Back-to-Back Housing	0.098	(0.004)
CornerHouse	0.034	(0.002)
Semi-Detached	0.127	(0.002)
Detached	0.318	(0.002)
Type of Apartment		
Split-Level (Ground Floor)	0.304	(0.004)
Split-Level (Upper Floor)	0.214	(0.004)
Maisonette	0.154	(0.005)
Porch Flat	0.210	(0.004)
Galary Glat	0.164	(0.004)
Elderly Flat	-0.113	(0.017)
Split-Level (Ground and Upper Floor)	0.291	(0.012)

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

Table 2.5: *List Price Hedonic Regression for 2007 (II)*

Parking (No Parking is base)		
Parking	0.063	(0.002)
Garage	0.109	(0.002)
Carport	0.117	(0.003)
Garden (South-East is base)		
No Garden	0.026	(0.002)
North Side	-0.011	(0.003)
North-East Side	-0.007	(0.003)
East Side	-0.012	(0.003)
South Side	0.000	(0.003)
South-West Side	0.009	(0.003)
West Side	-0.009	(0.003)
North-West Side	0.002	(0.003)
Miscellaneous		
Lift	0.063	(0.002)
Well Isolated	-0.017	(0.002)
Located to quiet road	0.005	(0.001)
Located to busy road	-0.009	(0.003)
Groundlease	-0.113	(0.002)
Quality Interior	0.038	(0.001)
Quality Exterior	0.011	(0.001)
Month Dummies (January is Base)		
February	0.006	(0.003)
March	0.016	(0.003)
April	0.025	(0.003)
May	0.035	(0.003)
June	0.036	(0.003)
July	0.036	(0.003)
August	0.036	(0.003)
September	0.048	(0.003)
October	0.047	(0.003)
November	0.050	(0.003)
December	0.047	(0.003)
Additional Controls	Yes	
R^2 Adjusted	80.4%	
Number of observations	176,589	

Note.–The dependent variable is log(list price). Additional controls are for region. There are 76 regions. These regions are defined by the Dutch NVM as an area wherein 80% of the people who move stay within the region. Standard errors are in parentheses.

2.8 Appendix: Haurin Atypicallity Variable

This appendix provides summary statistics for the Haurin(1988) atypicallity variable. The controls used in the hedonic regression to construct the atypicallity variable are number of rooms, log(lotsize), log(lotsize) squared, log(floorsize), log(floorsize) 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, groundlease, inside and outside quality of the house, and the NVM broker regions.

Table 2.6: *Descriptive Statistics*

	Mean	St.Dev.	Min.	Max.
Haurin atypicallity	0.015	0.085	-0.050	1.011

2.9 Appendix: Summary Statistics

Table 2.7: *Descriptive Statistics*

	Mean	St.Dev.	Min.	Max.
List-price premium	0.000	0.187	-0.487	0.461
Number of rooms	4.423	1.342	1.000	20.000
Log(lotsize)	4.164	2.442	0.000	13.816
Log(lotsize)^2	23.302	16.339	0.000	190.868
Log(floorsize)	4.753	0.340	3.714	6.290
Log(floorsize)^2	22.706	3.259	13.791	39.561
Quality Interior	7.081	1.159	1.000	9.000
Quality Exterior	7.097	1.065	1.000	9.000

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(lotsize), log(lotsize) squared, log(floorsize), log(floorsize) 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, groundlease, inside and outside quality of the house, and regions.

Table 2.8: *Frequencies (I)*

	Frequency
Construction Period	
Before 1905	0.725%
1906-1944	21.537%
1945-1990	61.328%
1991-2000	13.718%
After 2001	2.693%
Type of House	
Terraced House	30.219%
Back-to-Back Housing	2.193%
Cornerhouse	13.439%
Semi-Detached	14.830%
Detached	14.578%
Type of Apartment	
Split-Level (Ground Floor)	3.033%
Split-Level (Upper Floor)	5.563%
Maisonette	2.074%
Porch Flat	7.273%
Galary Flat	6.358%
Elderly Flat	0.156%
Split-Level (Ground and Upper Floor)	0.283%
Parking	
Parking	4.243%
No Parking	56.609%
Garage	28.723%
Carport	3.852%
Garden	
No Garden	34.257%
North Side	6.177%
North-East Side	4.404%
East Side	8.330%
South-East Side	7.632%
South Side	14.870%
South-West Side	9.899%
West Side	9.709%
North-West Side	4.722%

Table 2.9: *Frequencies (II)*

	Frequency
Miscellaneous	
Lift	7.033%
Well Isolated	77.620%
Located to quiet road	28.523%
Located to busy road	3.135%
Groundlease	5.415%
Province	
Groningen	4.253%
Friesland	3.490%
Drenthe	3.767%
Overijssel	6.769%
Flevoland	2.524%
Gelderland	13.315%
Utrecht	9.282%
Noord-Holland	18.434%
Zuid-Holland	20.450%
Zeeland	1.422%
Noord-Brabant	13.658%
Limburg	2.635%

2.10 Appendix: Further Estimation Results of the Baseline Model

This appendix provides further estimation results for the coefficients of the covariates of the baseline model.

Table 2.10: *Further Estimation Results of the Baseline Model (I)*

	Sale Hazard θ_s		Exit Hazard θ_w	
Size Characteristics				
Number of rooms	0.014	(0.003)	-0.010	(0.008)
Log(lotsize)	0.113	(0.004)	-0.456	(0.014)
Log(lotsize)^2	-0.004	(0.001)	0.030	(0.002)
Log(floorsize)	0.511	(0.161)	0.221	(0.412)
Log(floorsize)^2	-0.107	(0.017)	0.003	(0.042)
Construction Period (1991-2000 is base)				
Before 1905	-0.026	(0.035)	0.551	(0.082)
1906-1944	0.110	(0.009)	0.067	(0.027)
1945-1990	0.071	(0.008)	-0.096	(0.022)
After 2001	-0.281	(0.021)	-0.065	(0.044)
Type of House (Terraced House is base)				
Back-to-Back Housing	-0.210	(0.020)	0.039	(0.060)
Cornerhouse	-0.064	0.009	(0.047)	(0.031)
Semi-Detached	-0.155	0.010	(0.062	(0.031)
Detached	-0.571	0.012	(0.030)	(0.034)
Type of Apartment				
Split-Level (Ground Floor)	0.276	(0.018)	-0.700	(0.057)
Split-Level (Upper Floor)	0.329	(0.016)	-0.708	(0.047)
Maisonette	0.334	(0.022)	-1.136	(0.068)
Porch Flat	0.352	(0.016)	-1.073	(0.050)
Galary Glat	0.394	(0.018)	-0.963	(0.056)
Elderly Flat	-0.432	(0.064)	-1.676	(0.218)
Split-Level (Ground and Upper Floor)	0.073	(0.055)	-0.313	(0.127)

Note.–Standard errors are in parentheses.

Table 2.11: *Further Estimation Results of the Baseline Model (II)*

	Sale Hazard θ_s		Exit Hazard θ_w	
Parking (No Parking is base)				
Parking	-0.116	(0.014)	-0.060	(0.039)
Garage	-0.075	(0.008)	-0.014	(0.023)
Carport	-0.118	(0.015)	-0.045	(0.041)
Garden (South-East Side is base)				
No Garden	-0.130	(0.012)	0.051	(0.038)
North Side	-0.037	(0.015)	0.020	(0.049)
North-East Side	0.001	(0.016)	0.086	(0.053)
East Side	-0.008	(0.014)	0.048	(0.046)
South Side	0.013	(0.012)	0.031	(0.040)
South-West Side	0.016	(0.013)	0.032	(0.044)
West Side	0.002	(0.013)	0.045	(0.044)
North-West Side	-0.007	(0.016)	0.006	(0.053)
Miscellaneous				
Lift	-0.122	(0.014)	-0.151	(0.039)
Well Isolated	0.003	(0.007)	-0.107	(0.021)
Located to quiet road	0.034	(0.007)	0.002	(0.020)
Located to busy road	-0.084	(0.016)	0.026	(0.044)
Groundlease	-0.040	0.013	(0.008)	(0.038)
Quality Interior	-0.031	(0.004)	0.049	(0.012)
Quality Exterior	-0.006	(0.004)	-0.003	(0.013)
Province (Noord-Holland is base)				
Groningen	0.146	(0.015)	-0.263	(0.046)
Friesland	0.033	(0.008)	-0.199	(0.025)
Drenthe	0.010	(0.005)	-0.101	(0.016)
Overijssel	0.001	(0.003)	-0.106	(0.010)
Flevoland	-0.027	(0.004)	-0.059	(0.010)
Gelderland	0.012	(0.002)	-0.081	(0.005)
Utrecht	0.024	(0.002)	-0.034	(0.005)
Zuid-Holland	-0.005	(0.001)	-0.039	(0.003)
Zeeland	-0.007	(0.002)	-0.021	(0.007)
Noord-Brabant	0.013	(0.001)	-0.032	(0.003)
Limburg	-0.002	(0.002)	0.003	(0.004)

Note.–Standard errors are in parentheses.

Table 2.12: *Further Estimation Results of the Baseline Model (III)*

	Sale Hazard θ_s		Exit Hazard θ_w	
Calendar Time Dummies (1985 Q1 is base)				
1985 Q2	-0.077	(0.092)	-0.105	(0.328)
1985 Q3	-0.032	(0.091)	0.041	(0.313)
1985 Q4	-0.032	(0.090)	-0.005	(0.314)
1986 Q1	-0.050	(0.090)	0.017	(0.313)
1986 Q2	0.127	(0.086)	-0.113	(0.314)
1986 Q3	0.151	(0.087)	-0.199	(0.314)
1986 Q4	0.161	(0.088)	0.034	(0.310)
1987 Q1	0.209	(0.088)	-0.036	(0.311)
1987 Q2	0.217	(0.086)	-0.174	(0.314)
1987 Q3	0.158	(0.088)	0.003	(0.310)
1987 Q4	0.221	(0.088)	0.115	(0.308)
1988 Q1	0.345	(0.088)	0.022	(0.310)
1988 Q2	0.330	(0.086)	0.180	(0.309)
1988 Q3	0.296	(0.088)	0.028	(0.313)
1988 Q4	0.309	(0.087)	-0.073	(0.316)
1989 Q1	0.480	(0.086)	0.273	(0.311)
1989 Q2	0.497	(0.086)	0.122	(0.315)
1989 Q3	0.350	(0.088)	0.023	(0.316)
1989 Q4	0.343	(0.088)	0.012	(0.315)
1990 Q1	0.373	(0.087)	0.327	(0.308)
1990 Q2	0.286	(0.087)	-0.030	(0.314)
1990 Q3	0.391	(0.087)	0.113	(0.312)
1990 Q4	0.397	(0.087)	0.130	(0.313)
1991 Q1	0.362	(0.087)	-0.059	(0.316)
1991 Q2	0.605	(0.085)	0.132	(0.312)
1991 Q3	0.549	(0.086)	0.161	(0.313)
1991 Q4	0.522	(0.085)	0.102	(0.315)
1992 Q1	0.682	(0.085)	0.170	(0.315)
1992 Q2	0.768	(0.084)	0.089	(0.318)
1992 Q3	0.778	(0.085)	0.323	(0.315)
1992 Q4	0.758	(0.084)	0.143	(0.322)
1993 Q1	0.928	(0.084)	0.131	(0.320)
1993 Q2	0.920	(0.084)	0.449	(0.313)
1993 Q3	0.978	(0.084)	0.144	(0.321)
1993 Q4	0.939	(0.084)	0.131	(0.323)
1994 Q1	0.952	(0.083)	0.323	(0.317)
1994 Q2	0.809	(0.084)	0.417	(0.314)
1994 Q3	0.656	(0.085)	0.336	(0.314)
1994 Q4	0.697	(0.083)	0.143	(0.317)

Note.–Standard errors are in parentheses.

Table 2.13: *Further Estimation Results of the Baseline Model (IV)*

	Sale Hazard θ_s		Exit Hazard θ_w	
Calendar Time Dummies (1985 Q1 is base)				
1995 Q1	0.701	(0.083)	0.325	(0.313)
1995 Q2	0.715	(0.082)	0.503	(0.310)
1995 Q3	0.713	(0.081)	0.126	(0.317)
1995 Q4	0.738	(0.081)	0.163	(0.316)
1996 Q1	0.916	(0.080)	0.383	(0.317)
1996 Q2	0.844	(0.081)	0.781	(0.310)
1996 Q3	0.766	(0.081)	0.810	(0.310)
1996 Q4	0.660	(0.081)	0.422	(0.317)
1997 Q1	0.806	(0.081)	0.682	(0.312)
1997 Q2	0.675	(0.080)	0.768	(0.307)
1997 Q3	0.652	(0.080)	0.598	(0.309)
1997 Q4	0.476	(0.080)	1.134	(0.303)
1998 Q1	0.667	(0.080)	0.961	(0.305)
1998 Q2	0.643	(0.080)	0.690	(0.308)
1998 Q3	0.625	(0.080)	0.615	(0.309)
1998 Q4	0.648	(0.080)	0.541	(0.310)
1999 Q1	0.829	(0.079)	0.724	(0.308)
1999 Q2	0.813	(0.079)	0.540	(0.311)
1999 Q3	0.664	(0.080)	0.667	(0.308)
1999 Q4	0.484	(0.080)	0.756	(0.305)
2000 Q1	0.526	(0.080)	0.762	(0.304)
2000 Q2	0.474	(0.079)	0.427	(0.307)
2000 Q3	0.463	(0.079)	0.656	(0.303)
2000 Q4	0.351	(0.079)	0.549	(0.304)
2001 Q1	0.397	(0.079)	0.465	(0.304)
2001 Q2	0.360	(0.079)	0.574	(0.302)
2001 Q3	0.383	(0.079)	0.642	(0.302)
2001 Q4	0.430	(0.079)	0.871	(0.301)
2002 Q1	0.376	(0.080)	0.468	(0.304)
2002 Q2	0.280	(0.079)	0.514	(0.302)
2002 Q3	0.125	(0.079)	0.315	(0.302)
2002 Q4	-0.020	(0.079)	0.360	(0.301)
2003 Q1	0.056	(0.079)	0.493	(0.299)
2003 Q2	-0.124	(0.079)	0.302	(0.299)
2003 Q3	-0.280	(0.079)	0.193	(0.299)
2003 Q4	-0.397	(0.079)	-0.059	(0.299)
2004 Q1	-0.437	(0.079)	0.113	(0.298)
2004 Q2	-0.319	(0.079)	0.122	(0.298)
2004 Q3	-0.373	(0.079)	0.126	(0.298)
2004 Q4	-0.325	(0.079)	0.223	(0.297)

Note.–Standard errors are in parentheses.

Table 2.14: *Further Estimation Results of the Baseline Model (V)*

	Sale Hazard θ_s		Exit Hazard θ_w	
Calendar Time Dummies (1985 Q1 is base)				
2005 Q1	-0.339	(0.079)	0.222	(0.297)
2005 Q2	-0.302	(0.078)	0.161	(0.297)
2005 Q3	-0.304	(0.078)	0.109	(0.297)
2005 Q4	-0.276	(0.078)	0.255	(0.297)
2006 Q1	-0.252	(0.078)	0.260	(0.297)
2006 Q2	-0.312	(0.078)	0.164	(0.297)
2006 Q3	-0.326	(0.079)	0.217	(0.297)
2006 Q4	-0.328	(0.078)	0.198	(0.297)
2007 Q1	-0.268	(0.078)	0.219	(0.297)
2007 Q2	-0.310	(0.078)	0.124	(0.297)
2007 Q3	-0.329	(0.078)	0.177	(0.297)
2007 Q4	-0.413	(0.079)	0.118	(0.297)

Note.–Standard errors are in parentheses.

Chapter 3

Asymmetric Information and List Price Reductions in the Housing Market

This chapter is based on De Wit and Van der Klaauw (2010).

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 of many models for the housing market. In this paper, we estimate the causal effect of list-price reductions 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 probability of selling a house, but also the rate of withdrawal from the market increases.

3.1 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. This may not only be characteristics of the house, but may also relate to the seller. Sellers may, for example, differ in risk preference, financial constraints and patience. An important question is to which extent such 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 housing market. In the Netherlands list prices 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 will not have any effect on outcomes. However, in case of asymmetric information, the list price may signal some unobserved properties of the house or the seller (e.g. Albrecht, Gautier and Vroman, 2010). More patient sellers may, for example, set a higher list price than desperate sellers.

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 effect 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 list price are not exogenous, market thinness may also affect list price changes. 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 builds on Abbring and Van den Berg (2003) who show that identification of the causal effect of a list price change depends on the market 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. The actual list price reduction thus causes a shock to the market. 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 house prices are reduced, and it may be that during particular periods a house price reduction is more likely than in other periods. We thus 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.

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. This implies that we estimate the causal effect of a list price change on both the probability of selling the house and the probability of withdrawing the house from the market.

We use a unique administrative data set from 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). The data contain not only the initial list price, but are also informative on the moments 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 3.2 describes the institutional setting of the Dutch market for owner occupied houses. Section 3.3 describes our empirical model that is inspired by the theoretical literature. Section 3.4 describes the unique administrative data set. Section 3.5 presents the estimation results and some sensitivity analyses. Section 3.6 concludes.

3.2 Owner Occupied Housing Market in the Netherlands

In this section, we describe some institutions of the Dutch housing market. We mainly focus on 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 restricting on the loan-to-value ratio. Ball (2009) indicates that in 2007 the loan-to-value ratio of first-time buyers was 114%.

[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 currently for 30 years 100% deductable.

There are substantial transaction costs associated to 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 mortgage 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 on 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 also 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 list prices 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 some 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. It is not allowed to negotiate with multiple buyers at the same time or to reveal bids to other buyers. Furthermore, the seller should 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.

3.3 The Model

3.3.1 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. Lazear (1986) provides a two-period model in which list prices are actually important. Sellers face uncertainty about buyers' valuations, and learn in the first period. Therefore, second-period list prices are lower than in the first period. The price setting is related to market thinness. In a thin market, sellers receive less strong signals about the buyers' valuation. Therefore, they start with a lower initial price and prices decrease less rapidly. However, the model imposes that the object is sold to the first buyer who is willing to pay the list price. This assumption makes the model less suitable for the housing market. However, it indicates that list prices and list-price changes are often not exogenous.

Also Taylor (1999) develops a two-period model, but he allows for two-sided asymmetric information. Also in this model list prices are binding. The model is specified such that sellers cannot use the list price to signal the quality of their house. Houses that remain on the market for a long time become stigmatized, and can eventually be removed from the market as sale becomes unlikely. This is the consequence of buyer herding and information cascades, which can arise if second-period buyers do not observe list-price histories and inspections are not public. The latter might imply that high-quality sellers will reveal as much information as possible to the market, and low-quality sellers mimic their behavior. Indeed, empirical evidence confirms that the probability of sales decreases with time on the market (e.g. De Wit, 2009; Huang and Palmquist, 2001; Pryce and Gibb, 2006; and Zuehlke, 1987). However, withdrawal from the market is not exogenous to selling the house, and empirical analyses should take this into account.

Both Horowitz (1992) and Haurin, Haurin, Nadauld and Sanders (2006) presents a model in which buyers never bid above the list price. In both models bids arrive and sellers have to decide to reject or accept a bid immediately. Haurin, Haurin, Nadauld and Sanders (2006) assume that the rate at which bids arrive reduces in the level of the list price. Horowitz (1992) imposes that the distribution of bids depends on the list price, which could be interpreted as the seller revealing information about the (unobserved) reservation price to the market. Both models explain why sellers choose list prices, and expressions for the optimal list price are derived. However, the bidding behavior of buyers is very mechanic, and not driven by any underlying optimization.

Albrecht, Gautier and Vroman (2010) explicitly model the behavior of buyers in the housing market. They allow list prices to be used as signals. In their model sellers differ in the reservation value for their house, but this is private information. Such heterogeneity might arise because some sellers already hold a new house (e.g. Wheaton, 1990). Search of buyers is directed, so based on the list price they determine which house to visit. After visiting a house, buyers receives a match-specific value. In equilibrium, list prices reveal the seller's type. Sellers with a higher reservation value set a higher list price. Even though list price are not binding, the list price has both an effect of the selling price and the probability of sale. In particular, sellers who post a higher list price are less likely to sell their house, but receive a higher selling price. This only holds if sellers are heterogenous, and the source of heterogeneity is unobserved by buyers. If sellers would be homogenous, there would not be any role for list prices.

The key conclusion is that if list prices are not binding, in the absence of asymmetric information list prices do not play any role (Albrecht, Gautier and Vroman, 2010). This implies that the level of the list price does 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, the econometrician should explicitly take account of withdrawing as this might not be exogenous in a housing market of asymmetric information (Taylor, 1999).

3.3.2 Empirical Model

The main conclusion from the theoretical literature is that if list prices are not binding, they only play a relevant role in the case of asymmetric information. In particular, Albrecht, Gautier and Vroman (2010) show that list prices are used for signaling the (unobserved) seller type, and list prices are thus related to the probability of sale. 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 model to estimate the causal effect of a list-price change on the probability of selling the house (e.g. Abbring and Van den Berg, 2003). Furthermore, we jointly model withdrawals from the market, as Taylor (1999) shows that withdrawing a house may not be exogenous in a market of asymmetric information.

Before we provide the details of our econometric model, we first give a brief outline of the data. Our data contains houses which became for sale between January 2005 and December 2007. For each house we observed 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 possible list-price changes while the house was on the market. It should be noted that 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 case the list price is changed more than once.

Consider a house which is put on the market at (calender) 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 moment of 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 3.5.2 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

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

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

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

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. Although, it should be noted that 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 thus be constant. The parameters δ_s and δ_w are the key parameters of interest as these denote the causal effect of a list-price reduction on the rate at which houses are sold and withdrawn. In case of symmetric information, list prices should be irrelevant. Our test for symmetric information thus consist of testing if δ_s and δ_w are equal to zero.

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

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

The rate θ_p thus denotes the rate of lowering a list price if no list-price reduction has yet occurred while the house was on the market. The rate depends on the same set of observed characteristics x as the rate at which house are sold and withdrawn.

Now consider the joint distribution of t_s, t_w and t_p. Conditional on τ_0, x, v_s, v_w and v_p, the only possible relation between (t_s, t_w) and t_p is by way of the direct effect of a list-price change on the selling rate and the rate of withdrawal. In case of independence between (v_s, v_w) and v_p, we would have a standard competing-risks model for $(t_s, t_w)|x, \tau_0, t_p$ with $I(t_p < t)$ a time-varying regressor which is orthogonal to the unobserved heterogeneity (v_s, v_w). However, if (v_s, v_w) and v_p are not independent, inference on $(t_s, t_w)|x, \tau_0, t_p$ has to be based on $(t_s, t_w, t_p)|x, \tau_0$. Let $G(v_s, v_w, v_p)$ be the joint distribution function of the unobserved characteristics (v_s, v_w, v_p).

It is straightforward to derive the likelihood contributions from the specifications of the different hazard rates. The use of a flow sample of houses entering the market implies that we do not have any initial conditions problems. The right-censoring in the data is exogenous, 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 $i = 1, \dots, n$ denote the observations, then the loglikelihood function equals

$$\log \ell = \sum_{i=1}^{n} \log \left\{ \int_{v_s} \int_{v_w} \int_{v_p} \theta_s(t_i|x_i, \tau_{0,i}, v_s, t_{p,i})^{c_{s,i}} \theta_w(t_i|x_i, \tau_{0,i}, v_w, t_{p,i})^{c_{w,i}} \right.$$
$$\exp\left(- \int_0^{t_i} \theta_s(z|x_i, \tau_{0,i}, v_s, t_{p,i}) + \theta_w(z|x_i, \tau_{0,i}, v_w, t_{p,i}) dz \right)$$
$$\left. \theta_p(t_{p,i}|x_i, \tau_{0,i}, v_p)^{c_{p,i}} \exp\left(- \int_0^{t_{p,i}} \theta_p(z|x_i, \tau_{0,i}, v_p) dz \right) dG(v_s, v_l, v_p) \right\}$$

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 (2003) provide an extensive discussion on the identification of such models. The key identifying assumptions 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

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

This thus 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 thus does not imply that list-price reductions are exogenous, or that the rate at which list prices are reduced is continuous 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 thus 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.

It may be clear that in this setting the assumption of no anticipation is satisfied. Obviously buyers are not informed a priori about a list-price reduction. List-price reductions thus come as a shock. Furthermore, sellers do not know when potential buyers arrive and bid for their house. If the assumption of no anticipation is satisfied, no exclusions restrictions or very strong functional-form restrictions are necessary to identify the causal effects of list-price reductions. 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 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. 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 (2003) 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 3.5.2.

3.3.3 Parameterization

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,

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

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

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

with $p_1 + \ldots + p_K = 1$. For $K \geq 2$ this specification allows for dependence between the different unobservable 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.

3.4 The Data

Our data contain all houses and apartments offered for sale through all real estate brokers associated to 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 (5 periods), parking facility (4 types), garden location (9 types), and region (76 regions).[2] The data also include several size characteristics such as the floorsize, lotsize (in square meters), and the number of rooms in the house. Furthermore, we observe whether the dwelling is well isolated, type of heating system (3 types), location next to a quiet road, possible groundlease, presence of an elevator in the apartment building, and two variables measuring inside and outside quality on a discrete scale from 1 to 9. These quality measures are determined by the real estate broker selling the house.

Table 3.1: *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.

Table 3.1 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. It should, however, be noted that 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.[3]

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

[3]The 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 dwelling. The predicted log value of the list price is based on standard loglinear regressions separately performed for each year (e.g. Rosen,

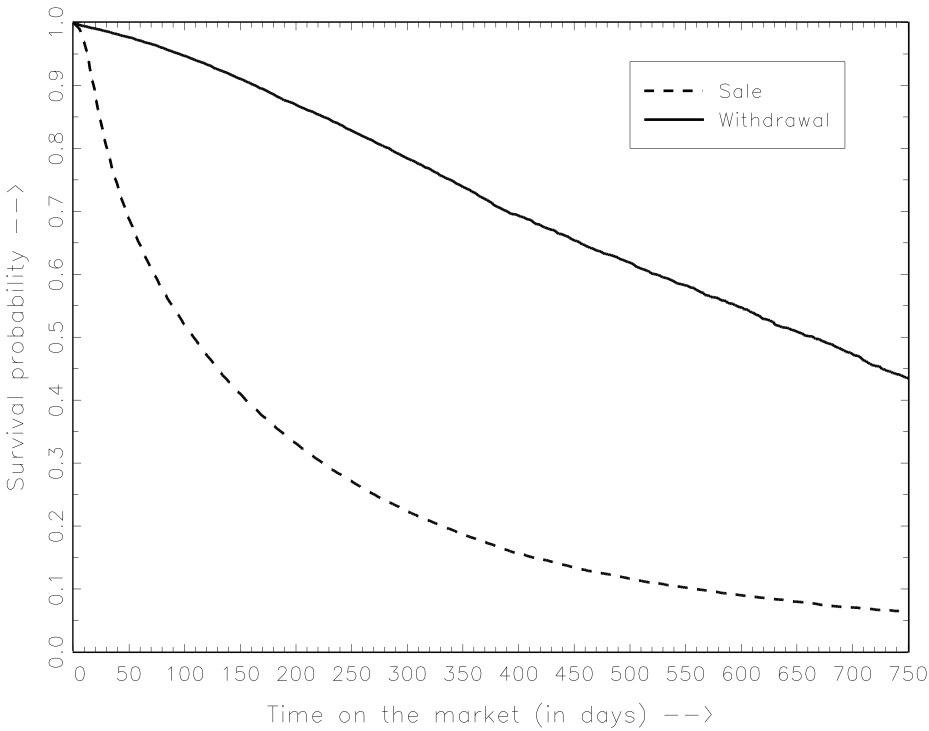

Figure 3.1: *Kaplan-Meier estimates for the survivor function to selling the house and withdrawal.*

Figure 3.1 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, withdrawing is considered to be exogenous, 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 is 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

1974). The R-squared for these regressions are 79.8%, 80.1% and 80.2% for 2005, 2006 and 2007, respectively. This approach is identical to that in Merlo and Ortalo-Magné (2004). The variable 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.

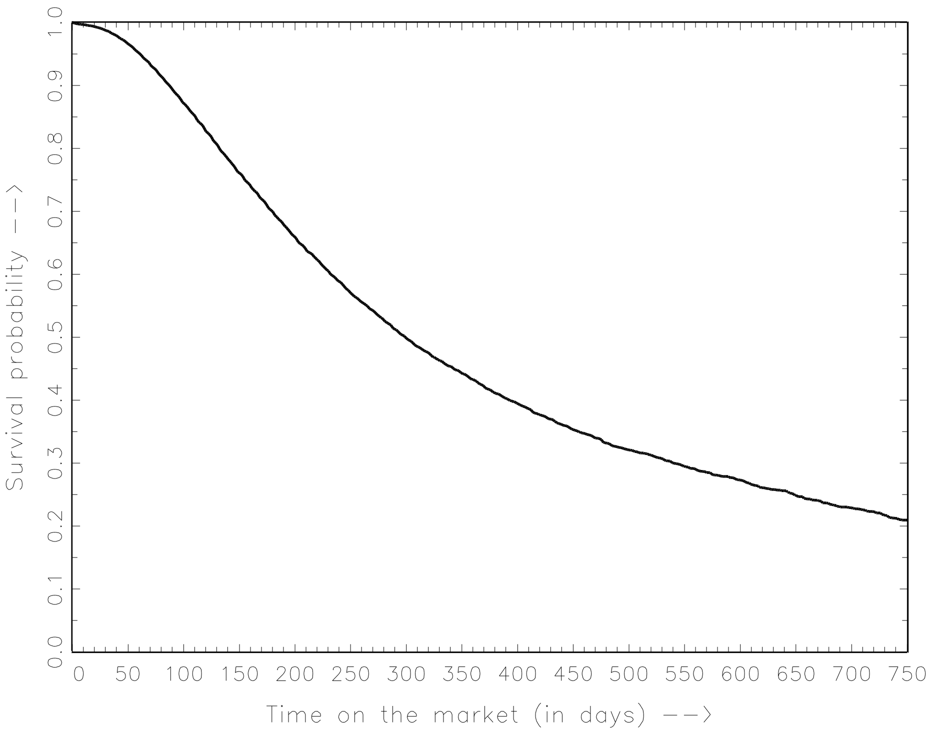

Figure 3.2: *Kaplan-Meier estimates for the survivor function for reducing the list price.*

the empirical analyses we only focus on the first list-price reduction. Figure 3.2 shows the survivor function for repricing the house. Within the first 100 days less than 13% of the houses is 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%.

3.5 Estimation Results

3.5.1 Parameter Estimates

In this section we discuss the results of our empirical analyses. 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 merge 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 3.2 presents the parameter estimates of our baseline model. The main parameters of interest are δ_s and δ_w, which represent the effect of a list-price reduction on, respectively, the rate at which a house is sold and withdrawn from the market. The parameter estimates show that a list-price reduction has both a positive and significant effect on selling the house and withdrawing the house from the market. 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 $(\exp(0.606) - 1) \times 100\% = 83\%$. A list-price reduction increases the rate at which the house is withdrawn from the market with $(\exp(0.366) - 1) \times 100\% = 44\%$. Recall that in a housing market with symmetric information, there is no important role for list prices. Our results indicate that list-price reductions have very substantial effects. This should thus be interpreted as evidence in favor of asymmetric information between sellers and buyers in the housing market.

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. This 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 seller 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 causes 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 might indicate that houses get stigmatized once they are for sale for a longer period. Stigmatization would imply the presence of a characteristic unobserved by buyers which might, for example, be revealed during inspections (e.g. Taylor, 1999). This might suggest asymmetric information, but it is not necessary that the seller has more information. An alternative explanation 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 similar to 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

Table 3.2: *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(lotsize), log(lotsize) squared, log(floorsize), log(floorsize) 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, groundlease, inside and outside quality of the house, and regions. Standard errors are in parentheses.

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, which real estate brokers consider as the best moment of selling a house. It might be that, therefore, real estate brokers advise sellers to reduces their list price in this quarter.

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 compare to an hedonic list price for the house. A positive list-price premium thus implies that the house is priced higher than comparable houses in the market. It should be stressed that 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). 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. 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 are sold and withdrawn from the market. The changes in these rates are quite substantial. In Table 3.3 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.[4] Column (1) shows that if list prices would never be reduced about 44% of all houses are sold within one quarter (and 3.2% of the houses are withdraw from the market). A list-price reduction after one month increase 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 182 days compared to

[4] 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 3.3: *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.

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.

3.5.2 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 dependency 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 plane in Table 3.4 it can be seen that not correcting for dependency 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 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 plane in Table 3.4 shows that the size of the list-price reduction has a positive

Table 3.4: *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.

and significant effect on selling the house. If the list price is more substantial the effect of the list-price reduction is larger. Recall from Section 3.4 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. It is important to stress that although these results provide some indication about the effects, it is difficult to draw strong causal conclusions. This is the case because 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 alow the effect depends 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 plane in Table 3.4 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 thus negatively affect the selling price. Other than this indirect effect, list-price reductions may 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

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

with

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

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. The unobserved heterogeneity term v_t can be correlated to the unobserved heterogeneity terms in the selling, withdrawing and repricing hazard to account for endogeneity. The parameters of interest are the direct effect of a list-price reduction δ_{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, Green and Paarsch (2000) who present hazard rate specifications as very flexible models for wages.

The bottom plane of Table 3.4 shows the estimation results for the main parameters of interest. First, it should be noted that 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 reduced the expected transaction price. 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 the 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 considered this distinction. First, we included a variable for atypical houses (using the Haurin, 1988; measure) in our model. This did not change any of the estimation results. In particular, the effects of the list-price reductions were unaffected. Second, we estimated the model again without atypical houses, which excluded 10% of the data. The effect of the repricing slightly changed 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.

3.6 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 (2003).

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-effects matter 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 thus 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 actually 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 merely an association than an causal effect.

Chapter 4

Price and Transaction Volume in the Dutch Housing Market

This chapter is based on De Wit, Englund and Francke (2010).

ABSTRACT

Housing markets typically exhibit a strong positive correlation between the rate of price increase and the number of houses sold. We document this correlation on high-quality Dutch data for the period 1985-2007, and estimate a VEC-model that allows us to study the mechanism giving rise to the correlation. The data identify the flows of new houses offered for sale as well as the number of houses sold. According to the estimated model, shocks to market fundamentals (the mortgage rate) have an immediate and significant impact on the rate of sale, little impact on the rate of entry of new houses for sale, and a gradual impact on the house prices. This pattern is consistent with a search model where buyers and sellers gradually learn about change in market conditions.

4.1 Introduction. Price-Volume Correlations

Between the mid 1980s and today real house prices more or less doubled in most industrialized countries. This has not been a smooth and continuous process. All countries experienced cycles where booms with price increases above trend were followed by busts with stagnating or falling prices. But price fluctuations alone do not fully characterize fluctuations in the housing market. In price booms, the market is typically also more liquid with frequent transactions and houses selling quickly, whereas in busts there are fewer sales and many houses remain on the market for a long time. Since the housing stock is fixed in the short run and most transactions are driven by households moving from one home to another, i.e. being present more or less simultaneously on both sides of the market, this is something of a puzzle. Figures 4.1 and 4.2 illustrate this pattern for the Dutch market for owner-occupied homes, based on the data being analyzed in this paper. Peaks and troughs of the number of sales and price changes coincide clearly in some periods (e.g. the trough in 1995 and the peak in 1999). Over other periods, however, the correlation appears to be weak. Once we relate sales to the number of houses for sale there is a much stronger correlation. Figure 4.2 shows that the rate of sale (sales divided by houses on the market) and price changes follow each other very closely (the correlation coefficient is 0.72).

Two main mechanisms have been advanced to explain the price-volume correlation. One is couched in standard demand-and-supply terms and associates more transactions with higher aggregate demand, e.g. because of released credit constraints that trigger moves up the housing ladder. The other approach emphasizes that the housing market is a search market where prices fail to clear the market at every instant and fluctuations in the number of sales primarily reflect changes in time-on-the-market rather than in underlying fundamentals.

Previous empirical studies have largely been confined to looking at data on prices and the number of sales, thereby being unable to assess the relative explanatory power of these two approaches to understanding the price-quantity correlation. In this paper we analyze detailed Dutch data that allow us to go behind number of sales and transaction prices. Market developments reflect the decisions of thousands of homeowners to offer their houses for sale and to set a reservation price that they are prepared to accept. At the same time, prospective homebuyers shop around for good deals. Given the search nature of the market, it does not clear continuously and variations in the time on the market and the rate of sale may accommodate inertia in prices. To understand the price-quantity correlation, it is therefore important to identify the flows of houses offered for sale as well as those sold, and to distinguish list prices set by sellers and sales prices accepted by both parties.

The data set analyzed in this paper is rich enough to contain observations on these variables for the entire Dutch housing market over a period of more than 20 years. For nearly two million dwellings sold between 1985 and 2007, we observe the original list price and the date when the dwelling was put on the market as well as the final sales price and the date of sale. This allows us to distinguish between the rate of entry of new houses onto the market - which would be the key variable if variations were due to underlying demand-and-supply fluctuations - and the rate of sale of houses on the market - which is an important indicator in a search market. Further, we may investigate any differences between the pattern of list prices - reflecting seller information and beliefs of market conditions - and sales prices - reflecting both seller and buyer information. Beyond providing descriptive statistics on these variables, we use our data to estimate a dynamic model of the Dutch housing market where prices and quantities are driven by disturbances to fundamental demand factors.

A main finding is that price changes are strongly positively correlated with the rate of sale but much more weakly correlated with the rate of entry of new dwellings for sale. We take this as *prima facie* evidence in favor of a search story over a demand-and-supply story. This is further corroborated by our estimates of the dynamic model. It shows that shocks to demand - the real mortgage rate - have an immediate but temporary impact on the rate of sale, a gradual and permanent impact on prices (both list price and sales price) and little impact on the rate of entry.

The next section of our paper reviews the empirical literature on the price-quantity correlation. Various theoretical explanations for this correlation have been advanced. In section 4.3 we briefly discuss the main candidates: the interaction between credit constraints and demand and supply, search - in particular combined with gradual adjustment of expectations - and loss aversion. Specifically, we discuss the observable implications of each theory. Next we present the data and some descriptive statistics in 4.4. Our empirical analysis is based on a vector-error-correction model. The model is specified in section 4.5 and the estimation results, primarily in the form of impulse-response functions, are presented in section 4.6. We conclude in section 4.7 that the results are consistent with the search-gradual-adjustment view but not with the credit-constraint theory.

4.2 The Empirical Evidence

The positive correlation between price changes and transaction volumes in housing markets is by now a relatively well established empirical regularity[1], primarily for US data but also for the UK and Sweden. In fact, realtors and other market actors seem to take the fluctuation between hot and cold markets - differing both in price development and sales activity - as a basic fact of life. While this general pattern is confirmed by most studies, the empirical picture is not without ambiguity. Some authors have looked at the simple correlation between price changes and number of sales. An early paper by Miller and Sklarz (1986), based on condominium data from Hawaii, shows that the rate of sale in one quarter is positively related to the price change in the next quarter; sales predict price changes. Two influential theoretical papers include a look at aggregate US data. Stein (1995) reports a significant relation between current sales volume and last year's rate of price change, i.e. a temporal lag in the opposite direction to that found by Miller and Sklarz. Berkovec and Goodman (1996) regress the change in median sales price on the simultaneous change in turnover, again with a significantly positive coefficient.

Other papers analyze dynamic econometric models with more structure. Follain and Velz (1995) find, counter to most other papers, price and sales volume to be nega-

[1] In contrast, commercial property markets do not appear to exhibit a price-volume correlation according to a study by Leung and Feng (2005) on Hong Kong office buildings.

tively correlated when put in the context of a structural model of housing market adjustment. Two papers study European housing markets. Hort (2000) finds no consistent relation between price changes and turnover changes using panel data for local housing markets in Sweden. Fixed effects regression on sales against the house price level yields negative coefficients at all frequencies. Hort goes on to investigate how shocks to fundamentals (represented by the after-tax mortgage rate) are transmitted into house prices and sales. Based on a VAR-model she concludes that an interest shock has an immediate negative impact on sales but affects prices only gradually. More recently, Andrew and Meen (2003) study aggregate UK data focusing on the adjustment to fundamentals within an error-correction framework. In a first stage, they estimate a long-run levels relation between price and fundamentals represented by income, supply, the number of households and construction costs. In the second stage, a two-equation conditional VAR-model is estimated where price change and the number of sales (as a fraction of the stock) are driven by deviations from equilibrium (the residuals of the first-stage equation). The results indicate that a shock to fundamentals impacts on sales and prices in the same direction. The sales effect peaks after about a year and sales revert back to their original equilibrium level after a couple of years. Prices, on the other hand, continue to fall for more than two years before turning and oscillating back towards the new equilibrium level.

Recent unpublished papers estimating dynamic models of price-sales adjustment include Clayton et al. (2008) and Wheaton and Lee (2009), both based on panel data of US local housing markets. Wheaton and Lee find that much of the variation in turnover is due to flows between rental and owner-occupied housing. In a search market context, one would also expect to see a connection between price volatility and turnover: the more uncertainty the higher should be reservation prices and the longer houses should stay on the market before being sold. Consistent with this Tu, Ong and Han (2009) find a negative correlation between volatility and turnover in their analysis of data on Singapore condominiums.

The papers reviewed above typically look at correlations at quarterly or yearly frequencies. Interestingly, there also seems to be a correlation in seasonal patterns. Ngai and Tenreyro (2009) document, both for US and UK data, that house price increases are systematically larger over the summer season (second and third quarters) than during the winter (fourth and first quarters)[2]. The difference is substantial, on the order of 5 percent annualized. Correspondingly, there is also a seasonal pattern in sales with increases during summer and decreases during winter. They also develop a search model of the housing market, where exogenous seasonal variations in mobility (e.g. related to the school year and moving costs) give rise to systematically higher prices in the summer due to improved matching between sellers and buyers (thick market effects).

[2]In contrast, a study on local UK housing prices by Rosenthal (2006) reports seasonal effects that are statistically insignificant in most cases.

4.3 Theories and Empirical Implications

There is no shortage of theories to account for the correlation between price and volume in housing markets. Broadly speaking one can identify three groups of theories. One theory focuses on the interaction between downpayment constraints, mobility and housing prices. Fundamental factors impact on demand and prices thereby releasing or tightening downpayment constraints, which will have a feedback effect on mobility and thereby on prices and the number of houses sold. A second set of theories regards the housing market as a search market that fails to clear instantaneously. A third theory suggests behavioral explanations for the price-quantity correlation. For example, if homeowners are loss averse and hence reluctant to lower asking price below the original purchase price, then the number of sales will decrease in a weak market. These theories are not mutually exclusive but can be combined with each other.

The link between credit constraints and the price-quantity correlation was first highlighted by Stein (1995). In his model the housing consumption of some households is restricted by downpayment requirements. A positive shock to fundamentals will increase housing prices thereby improving the equity position of incumbent homeowners and allowing them to trade up to a larger house. This would tend to increase mobility and transaction volume and thereby cause a further increase of prices and the volume of transactions. Conversely, a negative shock would depress prices and lock-in households and initiate a downward price spiral with even more households locked-in due to shortage of equity. Stein's argument is not developed within an explicit equilibrium model. This step was taken in the papers by Ortalo-Magné and Rady (1999, 2006), which integrate downpayment constraints within an overlapping-generations-model, where households move from starter homes to trade-up homes depending on income shocks and funding possibilities in the capital market. These models highlight the role of demographic factors like the relative size of different generations. They also have implications for variations in the relative prices of small and large houses. A key empirical implication is the feedback effect between price and quantity that arises as price changes strengthen or weaken credit constraints. Higher prices increase home equity and allow homeowners to afford the downpayment for a larger house. In an equilibrium setting with some households climbing up the market if they can afford, this model generates a positive correlation between sales (the fraction of households moving) and prices[3].

In these models causation runs from factors that release credit constraints to mobility and prices. The trigger may be a shock to house price fundamentals like interest rates, in which case one may expect house prices to react first and the number of transactions and further house price movements to follow. The trigger may also come from credit market conditions (like deregulation or financial innovations) that would have an immediate impact on mobility and sales and only a secondary impact on

[3] In Ortalo-Magé and Rady (1999) households can also move between owning and renting.

price. Consequently, it is not possible to say anything in general about the temporal structure. Depending on the underlying shock, Granger causality between price and quantity may run in either direction. Conditional on the shock, however, the theory has clear empirical predictions[4].

These models are usually formulated as equilibrium models with market-clearing prices. The story is not one of prices being slow to adjust and houses selling quicker or slower than usual during an adjustment period. The flow into the market of new houses for sale and the flow out of the market of houses sold are equally affected. In a modified version of the model, where one allowed for the sales process to take some time, one would expect sales to react first and entry of new houses for sale to come with a lag corresponding to the average time to sale.

Another set of explanations focuses on the nature of search and matching in the housing market. In the model of Berkovec and Goodman (1996) sellers are confronted with randomly arriving potential buyers. Neither party has a complete overview of the market. Sellers and buyers set their reservation prices reflecting their own personal economic situation and their expectations of the reservation prices of the opposite side of the market[5]. A transaction occurs if the buyer's reservation price exceeds the seller's asking price. Sellers and buyers are assumed to observe transaction prices but otherwise to be uninformed about underlying market conditions. They adjust their perceptions of the market price level gradually based on observed prices until a new stationary equilibrium is reached where prices conform to expectations and flows in and out of the market are equal. As a result, a demand increase (a higher arrival rate of potential buyers in the model) leads to an immediate increase in transactions followed by a gradual increase in reservation and transaction prices. Turnover remains above normal during the transition process to the new higher equilibrium price. In a stationary equilibrium, transaction prices adjust such that the number of houses on the market is constant, i.e. the arrival of new sellers exactly matches the number of houses sold. Since market shocks are assumed not to be observable to market participants, the model gives rise to a positive correlation between price change and turnover during the transition process. This property is driven by the assumption that price expectations do not fully reflect current market conditions but adjust mechanically to the difference between last period's price and the price that would be required in order to equate the rate of entry and exit from the market. Once in full equilibrium there is no price-volume correlation.

In a search market, a correlation between price and volume may also reflect variations in liquidity and the quality of matching between buyers and sellers. Many sales and more houses on the market should be associated with higher liquidity in

[4] It also implies that sellers with high loan-to-value ratios should tend to set higher asking prices and have longer times on the market. Genesove and Mayer (1997) find support for this prediction.

[5] A large literature deals with optimal pricing strategies; see e.g. Haurin (1988), Horowitz (1992), Knight, Sirmans and Turnbull (1994), Yavas and Yang (1995), Glower, Haurin and Hendershott (1998), Knight (2002), and Anglin, Rutherford and Springer (2003.)

the sense of a shorter time to sale and less price uncertainty. This connection has been analyzed by Krainer (2001) and Novy-Marx (2009) in a search market context. Krainer explicitly models the fact that individuals are typically on both sides of the market. The decision to sell and buy is driven by a stochastic process indicating if the household is well matched or not with the particular housing unit it occupies. The value a household derives from a house depends on two factors: an idiosyncratic component and a market fundamentals component that is common to all households. Buyers and sellers follow optimal pricing and search strategies. The higher are market prices, as driven by fundamentals, the higher is the opportunity cost of not being matched and the more eager are buyers and sellers to set reservation prices so as to ensure quick transactions. This leads to the conclusion that sales, liquidity and prices are positively correlated. This conclusion depends crucially on the, realistic, assumption of the absence of a well functioning rental market that households could turn to in order to satisfy their demands for housing. If households could move between owning and renting at no cost, then the opportunity cost of not having found a house to buy and live in would vanish and there would be no correlation between price and liquidity. The matching model of Novy-Marx emphasizes that a demand increase, represented by an inflow of buyers, will increase the match rate between buyers and sellers. This will also have a feedback effect on the ratio of buyers to sellers that further reinforces the initial price impact.

Another explanation for the price-volume correlation derives from behavioral considerations. A couple of studies have found evidence that homeowners have an aversion to making losses. Genesove and Mayer (2001) and Engelhardt (2003) represent seller behavior by prospect theory implying that the marginal disutility of losses exceeds the marginal utility of gains. If this is so, sellers should be reluctant to setting an asking price below their original purchase price. Both papers find empirical support for this hypothesis. Genesove and Mayer analyze detailed data on condominium sales in Boston and find that owners with nominal losses set higher list prices and accept longer selling times than other sellers. Engelhardt, using nationwide US data, finds that loss aversion has a significant impact on intra-metropolitan mobility. On the other hand, Englehardt does not find evidence of a connection between equity and homeowner mobility, in contrast with theories emphasizing credit constraints.

These three broad approaches are of course not mutually exclusive. The credit constraint story is about the balance between demand and supply in the market and is typically told assuming immediate market clearing, but it could of course be enriched by adding a search process. The loss aversion theory was tested by Genesove and Mayer in a search setting but could also be told in a world of clearing markets where houses with lower reservation prices were simply not entered onto the market.

Most previous empirical studies of the price-volume correlation have been confined to looking at the aggregate number of sales and transactions prices. As a consequence, they have been limited in their ability to discriminate between the different underlying mechanisms. In contrast, our Dutch data include information about both list prices and transaction prices as well as the number of new houses offered for sale and the number of completed sales. This allows us to provide more detail about the dynamics of the housing market adjustment process than in earlier studies. Like Hort (2000) and Andrew and Meen (2003) we focus on the transmission process from news about fundamentals to house prices and transaction volumes. But unlike these and other earlier studies we are able to decompose the variation in the number of houses sold into variations in the number of houses entered onto the market (the rate of entry) and the probability of sale. Further, we can test whether new information first gets incorporated into list prices or sales prices.

The theories presented in the previous section differ in their empirical implications. The credit constraint view is basically an equilibrium story, where shocks to fundamentals more or less simultaneously increase prices and induce more trades. Causality goes from fundamentals to prices and houses bought and sold with feedback effects back to prices. The key empirical prediction is that shocks to fundamentals should have an impact on the entry of new houses onto the market (and on price). The theory has nothing to say about the micro structure of markets, i.e. it does not yield predictions about the rate of sale.

Among the search models, there are two distinct mechanisms. One is an equilibrium story: the more houses there are on the market the higher is liquidity and the easier it should be, ceteris paribus, to find good matches between buyer and seller. This implies that in a more liquid market, with a higher rate of entry of new houses onto the market, the rate of sale should be higher and possibly also prices. This reasoning presumes that the sellers of these houses also appear on the other side of the market as sellers, i.e. it presumes a closed market with no migration. For this reason, it is not straightforward to test the equilibrium search model without auxiliary assumptions about the nature of shocks.

There is also an imperfect information search mechanism, associated with Berkovec and Goodman (1996). This emphasizes the adjustment process outside of equilibrium. In one version of this theory, buyers demand is affected by shocks to fundamentals but neither buyers nor sellers are fully informed about (or capable to infer) the market consequences of changes in fundamentals. They will adapt their expectations about market equilibrium prices only gradually as a result of observed transaction prices and time on the market. Shocks to fundamentals would have an immediate impact on the reservation prices of buyers but a delayed impact on the reservation prices of sellers. As a result the rate of sale would shoot up immediately but prices would only move gradually. There might also be a secondary impact on the entry of new houses onto the market to the extent that a purchase is followed by a sale.

4.4 Prices and Quantities in the Dutch Housing Market

In this section we present the data used in our study and display some descriptive statistics, thereby sketching the history of the Dutch housing market since the mid-1980s. Our main source is a data base maintained by the Dutch Association of Real Estate Brokers and Real Estate Experts (NVM). NVM organizes the majority of real estate brokers in the Netherlands. Today the organization has more than 4000 members. Together, NVM brokers handle more than half of all transactions of owner-occupied homes. The market coverage has been growing over the years, from 25-30 percent in the 1980s to 55-60 percent today. Membership is unevenly distributed across the country. In Amsterdam the NVM market share is now 75 percent, substantially higher than in more rural regions.

Member brokers are required to report to NVM all dwellings (apartments and one-family houses) offered for sale. Information given includes the initial asking price and the date the house was put on the market as well as the date and price of sale[6]. For an unsold house the date of withdrawal from the market is recorded. The records also include the exact address, an exhaustive list of physical characteristics and subjective assessments of the standard of the dwelling.

4.4.1 Prices

Based on the NVM data we compute two hedonic nationwide price index series: one for the initial list price and one for the final transaction price. The original data base contains 3,074,368 observations on dwellings offered for sale during the period January 1985 - December 2007. After deletion of data with missing observations and some outliers, we make use of 1,950,666 observations for the list price regressions and 1,890,633 observations for the sales price regressions. The index estimates are based on log-linear hedonic regressions performed year-by-year using monthly dummies. Geographical price variation is controlled for by 76 regional dummy variables. Details on the index estimation are given in 4.8.

The sales price regression has somewhat better fit in every year, although the regression coefficients are quite similar for the two regressions. The average R2-value of the sales price regressions is 0.813 compared to 0.799 for the list price regressions. In general, there seems to be more noise in prices in times of price increase. Both hedonic equations are more successful in cold than in hot markets. In 1994-96, when prices were stagnating, the average R2 was 0.826 for the sales price equation (and 0.818 for the list price equation) compared with the hot years of 1999-2001 with an average R2 of 0.806 (0.777).

We link the within-year index series using the mean characteristics of all transacted

[6]There is also some information about intermediate asking prices. This information appears to be incomplete for part of the sample period, however, and it is not used in this paper. De Wit and van der Klaauw (2009) analyze the process of list price revision.

dwellings during the year and form Laspeyres price indexes. The results are depicted in Figure 4.3. Our data cover a period when Dutch prices were more or less continuously increasing, almost three-fold from 1985 to 2007. This relatively smooth growth is in contrast to many other markets - notably UK and the Scandinavian countries - that saw prices falling in nominal terms in the early 1990s, and others - including the US, UK and Spain - that have experienced sharp price reductions in recent years. Part of the reason for the difference may be the severe housing market crisis in the Netherlands in the early 1980s, when prices fell by a third between 1978 and 1982. As a result the Dutch housing price level was quite depressed in 1985 when our data start, most likely below its long-run equilibrium level. Some of the subsequent price rise may hence be seen as a catch-up effect. When prices fell dramatically in other countries in the early 1990s they were only dropping slightly in the Netherlands. Subsequently, prices shot up sharply again from the middle of the decade with the rate of yearly price growth gradually increasing to around 7 percent in 1998. Prices stagnate again after 2000, but continue to increase slightly until the end of our data. The price increase went on past the sample until reaching a peak in the middle of 2008, followed by a modest price fall by 4 percent until the second quarter of 2009 (according to the price index published by the Central Bureau of Statistics).

4.4.2 List Prices and Sales Prices

In the Dutch market, the list price represents a commitment from the seller to sell at the posted price. Apparently this is not strictly binding and the data set has some observations where the sales price exceeds the asking price. The great majority of dwellings, however, were sold below (86.1 percent of all sales) or exactly at (9.6 percent) the list price. Only 4.3 percent of all sales prices exceed the list price. Prices in excess of the list price were somewhat more common in the late 1990s when prices were increasing generally. The two price indexes follow each other rather closely as seen in Figure 4.3. The discount of transaction price relative to list price - calculated as the log difference between the transaction price index for houses that were sold in month t and the list price index for houses entered on the market in month t-2 (two months being the mean lag from entry to sale) - is shown in Figure 4.4. The discount has fluctuated between 5.5 and 13 percent. The variation appears to reflect a combination of trend and cyclical developments. There are local peaks corresponding to the periods of stagnating prices in the early 1990s and early 2000s as well as a low mark in the boom market of the late 1990s when the rate of price increase was at its highest. At the same time there is a trendwise development with a much lower discount in recent years than at the beginning of the sample period, perhaps reflecting changing market institutions.

4.4.3 Houses for Sale and Houses Sold

In calculating time series of houses sold and houses on the market, we have to account for the fact that the NVM market share has increased during the sample period. Thus, new houses entered into the data base partly reflect new brokers entering the

NVM reporting system. We have corrected for this based on information on the total number of sales obtained from the Dutch Land Registry (the Kadaster). The correction is based on the presumption that sales through NVM brokers are representative for all sales, i.e. that there are no systematic differences between NVM brokers and other brokers. Details of the correction are described in Appendix 4.9.

Figure 4.5 depicts the rate of sale, defined as the number of houses sold during one month divided by the number of houses on the market in the beginning of that month. The rate of sale increased gradually, interrupted by a minor decrease in the mid 1990s, from below 20 percent in the 1980s to close to 50 percent when the rate of price change peaked in late 1998. In that hot market, many houses literally sold immediately when they were entered onto the market. Subsequently the market calmed down with stagnating prices, and the rate of sale fell back to below 20 percent after 2002. Overall, as we saw from Figure 4.2, the correlation between the rate of sale and price increases is quite strong.

Whereas the rate of sale is a natural measure of market liquidity it does not tell the whole story about the total number of houses sold. By definition, the number of sales equals the rate of sale times the number of houses on the market, and the percentage change in number of sales is, hence, approximately equal to the sum of the rates of change of the rate of sale and the number of houses on the market. Figure 4.6 illustrates this decomposition of (the 12-month average of) the change in the number of sales. The change in the number of sales and the rate of sale follow each other very closely with a correlation coefficient as high as 0.96. The correlation between the change in sales and the change in houses for sale, on the other hand, is only 0.34. Variations in sales seem to be driven by variations in the match rate between buyers and sellers rather than by variations in the flows of houses in and out of the market.

The change in the inventory of houses for sale is the net result of three gross flows in and out of the market: new houses for sale, houses sold, and withdrawals of unsold houses from the market. Expressing these flows as fractions of the number of houses on the market, it holds identically that the rate of change of number of dwellings on the market $\equiv$ the rate of entry - the rate of sales - the rate of withdrawal. These flows are depicted in Figure 4.7. The first thing to note is the magnitude of the gross flows relative to the net change in the number of houses on the market. In any month, the new houses for sale entered onto the market correspond to between 10 and 50 percent of all houses on the market, but at the same time almost as many houses are sold. As a result, the number of houses on the market rarely changes by more than 1-2 percent up or down in a single month. The strong correlation between the gross flows is natural since most transactions are related to household moves from one house to another[7]. Withdrawals, in contrast, play a minor role for the development of the

[7]Mobility within the owner-occupied market is far from the whole story, however. For US data Wheaton and Lee (2009) find that rent-to-own and own-to-rent flows are each as large as own-to-own flows.

stock; in any month only between 3 and 5 percent are withdrawn from the market[8]. Over time, however, even small imbalances between the flows can add up to significant changes in the inventory of houses on the market. In fact, from 1985 to 1996 the inventory decreased by as much as two thirds from 180,000 to 60,000. Starting around 1993 gross flows increased sharply. The rates of entry and sale both doubled from 20 to 40 percent. At the same time the difference between the rate of entry and the rate of sale again got larger and the number of houses more than doubled to reach 150,000 in 2005. At the end of the sample period in 2007 the inventory was again down below 100,000. In the recent housing bust, sales have fallen by almost 50% from mid 2007 to mid 2009.

For our econometric analysis we would like to identify exogenous shocks to the entry of new houses as one of the drivers of prices. From that perspective, it is preferable to define the entry rate as the number of new houses for sale divided by the total stock of houses in the economy (rather than, as in Figure 4.7, divided by the number of houses for sale on the market, which is endogenous). The rate of entry defined in that manner is depicted in Figure 4.8. We see that generally between 0.3 and 0.4 percent of the total housing stock is entered onto the market in every month. There are strong seasonal variations with troughs in December and peaks in March. Beyond that, there is some low-frequency variation with a gradual decrease in the rate of entry until the mid 1990s, a gradual increase until the turn of the millennium and a slight decrease thereafter. The increase in the entry rate between 1995 and 2000 roughly coincides with the increase in the rate of price change during the same period. There is a positive correlation between the rate of entry and price changes, but not at all as strong as between the rate of sale and price changes.

4.4.4 Fundamentals

The key issue of our analysis is understanding the transmission process from underlying shocks to house price fundamentals onto prices and sales. Fundamentals should include the main determinants of demand and supply. Other studies of Dutch housing prices, including Boelhouwer et al. (2001), Kranendonk and Verbruggen (2008), and Francke et al. (2009), all represent the demand side by the real interest rate and an income variable, both of which are strongly significant in determining long-run house prices. Kranendonk and Verbruggen also include net financial wealth and a measure of supply. As we are interested in capturing high-frequency (monthly) price and quantity movements, we are somewhat limited in our access to data. In particular, monthly income data are not available. Instead we include unemployment, measured by the three-month moving average of the open rate of unemployment (source: the Central Bureau for Statistics, CBS). This series is depicted in Figure 4.9. It combines a falling long-run trend from 10 to 2 percent from the beginning to the end of the sample period with short-term cycles with peaks around 1993 and 2004.

[8] De Wit (2009) studies the duration-dependence of the hazard rates of sale and withdrawal.

Interest is measured by the monthly average across all new five-year fixed rate residential mortgages (source: the Central Bureau for Statistics, CBS). We convert this into a real interest rate by deducting a measure of the expected rate of inflation, constructed from an ARMA (7,7) model with monthly dummies. We make 60-month ahead forecasts of the inflation rate. We compound and annualize these forecasts and deduct them from the nominal interest rate. The resulting series is depicted in Figure 4.10 along with the original nominal interest rate. The inflation correction corresponds, by and large, to a parallel downward shift by around 2 percent, reflecting the fact that inflation fluctuations have been modest. The general pattern of the interest development is somewhat similar to that of unemployment: a falling trend, from 6 to 2 percent during the sample period, combined with cyclical peaks. But the correlation between unemployment and interest is far from perfect. In particular, the years after 2000 exhibit falling interest rates along with increases in unemployment.

As we will see from the econometric model, both interest and unemployment are significant in explaining house prices in the long run. Shocks to the unemployment rate, however, seem to have little impact on the short-term dynamics of the model. As an alternative we tried using a broader business cycle indicator taken from den Reijer (2006), but with similar results.

4.5 Econometric Modeling

The correlation between price and sales reflects both short-run fluctuations and long-run trends. We need an econometric framework that allows us to model long-run determinants of the underlying equilibrium as well as short-run deviations from this equilibrium. The natural vehicle for such analysis is a vector error-correction model (VECM), where the dynamics are given by the combination of current and past shocks and the gradual adjustment towards equilibrium. This model presumes that the variables included are non-stationary but cointegrated, meaning that linear combinations of the variables are stationary. These linear combinations can be interpreted as equilibrium relations. A VECM can be written as

$$\Delta y_t = \mu + \alpha[\beta' \eta] \begin{bmatrix} y_{t-1} \\ t-1 \end{bmatrix} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \Phi D_t + u_t, \tag{4.1}$$

where y is a *(K×1)* variable vector. In our case *K=6* and the vector y consists of the variables described in the previous section: two prices - the real list price lp and the real transaction price tp (both in logs); two quantity variables - the rate of entry e (defined as the number of new houses for sale divided by the total stock of houses) and the rate of sale s (defined as the number of houses sold divided by the number of houses for sale on the market); two fundamentals - unemployment u and the real mortgage interest rate i (both in logs)[9]. The *(K×1)* vector μ consists of constants,

[9]We have also estimated a seven-variable VEC-model also including the rate of withdrawal. This variable, however, was generally insignificant and did not affect other properties of the model. Hence,

and the *(K×r)* matrices α and β are the loading and the cointegration matrix, respectively, where r is the number of cointegrating relations and β'y are the cointegrating relations. The vector η is a time trend to allow for the influence of omitted variables. The Γ matrix contains the short-run parameters. The matrix D consists of centered seasonal dummies and the matrix Φ is the corresponding coefficient matrix.

The data set covers all NVM transactions from January 1985 to December 2007. For the econometric analysis we exclude all observations for 1985, since it is not possible to construct a reliable measure of the inventory of houses on the market for this year. Such a measure would have to be computed based on reported market flows in 1984 (and possibly earlier) when reporting was incomplete. Further, we also exclude the last six months of 2007. The reason is that brokers only report to NVM once an entire spell from entry to sale or withdrawal is completed. This implies that observations for the last few months of the data base would have an over-representation of short spells. To avoid having our results contaminated by this we exclude observations at the end of the sample[10].

To specify the model we first test the variables for stationarity. Results are shown in Table 4.1. We are unable to reject the null hypothesis of non-stationarity for five of our six variables: the two prices, interest, unemployment and the rate of sale. All these variables are stationary in differences. For the rate of entry e, on the other hand, we reject non-stationarity at the 2 per cent level. It may seem somewhat inconsistent to treat the rate of sale as an I(1) variable and the rate of entry as I(0). But since the entry rate primarily reflects mobility and is normalized by the stock of houses, whereas the sales rate reflects market liquidity and is normalized by the number of houses on the market, there is nothing inconsistent in having different orders of integration. It should be noted, however, that it implies that there are no long-run linkages between the rate of entry and the other variables in the model.

We expect the non-stationary variables to be linked together in the long run by equilibrium conditions. Table 4.2 reports Johansen (1996) trace tests for the number of cointegrating vectors. In the tests we exclude the stationary variable e. The null hypothesis of two vectors is rejected in favor of three or more vectors (p-value = .03), but the null of three vectors is not rejected (p-value = .86). The test reported in the table is based on 3 lags, which is the optimal lag length in the model (including the rate of entry) according to different criteria (Akaike Info Criterion, Final Prediction Error and Hannan-Quinn Criterion). The test results for the number of cointegrating vectors are robust to the choice of lags. Consequently, we base our VEC-model on three cointegrating vectors.

In estimating the model, we impose restrictions on the cointegrating vectors that allow us to interpret the vectors as economically meaningful equilibrium conditions.

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we are only reporting results from the six-variable VEC-model.

[10]This exclusion has some impact on the estimates. In particular, the restrictions we put on the cointegrating vectors would be rejected if we used the full data set up to 2007:12.

Specifically, we estimate three exactly identified vectors based on the following assumptions:

- The transaction price is determined by the fundamentals: there is a cointegrating relation between *tp*, *u* and *i*.
- The ratio of list price to transaction price is determined by the fundamentals: there is a cointegrating relation between *tp*, *lp*, *i* and *u* with the coefficients for *tp* and *lp* restricted to plus and minus one.
- The transaction price is related to the rate of sale and the interest rate: there is a cointegrating relation between *tp*, *s* and *i*.

Imposing these restrictions, we estimate the model by the maximum-likelihood approach proposed by Johansen[11]. All equations include monthly dummies and a linear trend. The model also includes the rate of entry, which is treated as a stationary variable. Table 4.3 provides the estimation results for α, β and residual standard errors and cross correlations, using the effective sample from January 1986 to June 2007.

We think of the fundamentals as the basic driving forces and the price and quantity variables as indicators of the state of the market. The distinction between fundamental determinants and endogenous market responses is not clear-cut, however. The model allows analyzing the impact of shocks to all six variables, including the market indicators. Shocks to the price and quantity variables represent market impulses that are not due to interest and unemployment shocks. The rates of sale and entry are affected by mobility. An increase in emigration or in the transition from owning to renting would put more houses on the market, i.e. be reflected in a shock to the rate of entry. An increase in immigration or in the transition from renting to owning would, all else equal, mean that houses sold more easily, i.e. show up as a shock to the rate of sale. A pure mobility shock - e.g. due to lower transaction costs - would mean a more or less simultaneous shock to both sides of the market and affect both the rate of entry and the rate of sale. If households typically would buy a new house before selling their old house, as is often assumed in search models of the housing market following Wheaton (1990), then an intra-market mobility shock would affect the rate of sale immediately and the rate of entry with a lag of a couple of months.

How are fundamental shocks transmitted into market indicators? How do prices and quantities react to shocks? How important are different shocks in explaining the variation in prices and quantities? The answers according to the estimated model can be illustrated by means of impulse response functions, showing the impact of one-standard-deviation shocks to the error term. Variance decompositions split the variance in forecast errors into the contributions from the different shocks. To allow meaningful interpretation, the shocks are orthogonalized so as to be uncorrelated with

[11] The estimation is performed using CATS for RATS version 7.10. The stationary variable e is included in the vector y. For this variable we have a column in matrix β with a unit in one position and zeros elsewhere; see Lütkepohl (2006) for more details.

each other. The orthogonalization is based on the assumption that the simultaneous interaction between the variables has a recursive structure, i.e. a Choleski decomposition. Since results may be sensitive to the recursive ordering we have calculated impulse responses and variance decompositions for the following four orderings

- u, i, e, s, lp, tp
- u, i, e, s, tp, lp
- u, i, s, e, lp, tp
- u, i, lp, tp, e, s.

In all orderings the macroeconomic variables u and i go first, as our main focus is on understanding how shocks to these are transmitted into prices and quantities. In cases 1-3 they are followed by the quantities (entry and sale), with the prices coming last. Cases 2 and 3 differ from case 1 by reversing the ordering between the list price and the sales price (case 2) and between the rate of entry and the rate of sale (case 3). In case 4, finally, the ordering between the block of prices and the block of quantities is reversed.

4.6 Results

Details of the estimated model are given in Table 4.3. Let us first look at the equilibrium properties represented by the cointegrating relations and then go on to study the dynamics of the model.

4.6.1 The Cointegrating Relations

Imposing exactly identified coefficient restrictions as discussed in the previous section, we get the following estimates of the cointegrating vectors.

$$tp = -0.232u - 0.264i + 0.002t \tag{4.2}$$

$$lp - tp = -0.0011u - 0.017i - 0.0002t \tag{4.3}$$

$$tp = 0.331i - 2.150s + 0.006t \tag{4.4}$$

The first equation can be interpreted as a reduced form price equation. The equilibrium elasticities of price with respect to unemployment and interest are -0.23 and -0.26, respectively. There is a positive price trend of 0.2 per cent per month reflecting the influence of income, demographics and other factors not present in the model. The models of Krankendonk and Verbruggen (2005) and Francke et al. (2009) both find income elasticities on the order of unity. Combined with a period of income rising with a couple of percent per year, this translates into a positive price trend comparable to the one we have estimated. The interest elasticity is higher than the -0.086 estimated by Francke et al in their one-equation error-correction model.

The second equation gives the equilibrium elasticities of the premium of list price over sales price as a function of interest and unemployment. Both elasticities are negative; the higher is the interest rate (the cost of waiting) and the higher is unemployment the more eager are households to sell quickly and the lower is the list price relative to the sales price. The elasticities may seem quite small, 1.1 and 1.7 percent, respectively. But remember that these are elasticities of the ratio of list price to sales price (not of the premium). To get a sense of the magnitudes consider the impact of the real interest rate falling from its peak value of 7.5 per cent (recorded in 1990) to the lowest value of 1.2 percent (in 2005). A change of this magnitude would cause the ratio of list price to sales price to fall by 3.1 percent. This effect should be related to the fact that the list-to-sales-price ratio has fluctuated between 1.057 and 1.024, i.e. a fall in this ratio of 3.1 percent is equivalent to a fall in the list price premium from its maximum to its minimum observed value.

Finally, according to the third equation, an increase in the rate of sale by one percentage point is accompanied by a decrease in the sales price by two percent. Despite the fact that monthly observations of the price changes and the rate of sale are positively correlated, we find a negative long-run relation between these variables. This runs counter to the idea that the positive short-run correlation reflects a liquidity premium. It should be pointed out, however, that caution is needed in giving structural interpretations to the cointegrating equations. Indeed, any linear combination of two cointegrating vectors is also a cointegrating vector.

The residuals from the cointegrating relations are displayed in Figures 4.11 - 4.13. In the latter half of the 1990s, when interest and unemployment rates both were falling, the residual of the first equation went from positive to negative. Interpreting this as deviations from the fundamental market price, this indicates that house prices went from over- to under-valuation. As prices continued to increase despite interest rates picking up from 1999, under-valuation quickly turned into over-valuation. After that the residual has been quite volatile. Following several years of stagnating house prices after 2000, our model indicates that Dutch house prices were in fact under-valued in relation to fundamentals by 7 percent in 2007. The residuals from the second equation indicate that the list price premium was below its fundamental value in the period of increasing sales prices in the late 1990s, perhaps reflecting that prices were increasing faster than expected when list prices were set. Conversely, there was a large premium, i.e. sales prices were low relative to list prices, when the market was stagnating in the early 1990s and after 2000.

4.6.2 Impulse Responses

The dynamic properties of the model are illustrated by means of impulse response functions and variance decompositions. The impulse responses show the predicted dynamic paths following on a one-standard-deviation shock, orthogonalized according to either of the recursive schemes stated above. By and large the results are insensitive to the ordering of shocks and we will focus on the first ordering. As a further robustness check, we have also computed, for the first ordering, impulse response functions based on a model with no restrictions on the cointegrating vectors. With one exception (the impact of the rate of entry on price), the results are similar to the results based on the restricted long-run model.

The entire sets of impulse responses for the different orderings are reported in Appendix 4.10 with 90-percent confidence intervals computed using the method proposed by Sims and Zha (1999). Here we will focus on discussing the most important impulse responses. Among the two fundamentals we get the clearest results for interest shocks. A one-standard-deviation interest shock leads to a permanent increase of the mortgage rate by 4 per cent (equal to 15 basis points at sample mean). The responses of the transaction price and the rate of sale are depicted in Figures 4.14 and 4.15. The trajectory for the list price is almost indistinguishable from that of the transaction price, and there is no indication of the list price leading or lagging the sales price. In other words, new information seems to be incorporated into both prices simultaneously. Comparing the price and quantity responses, we see a clear contrast. While the impacts on prices are gradual but lasting, the impact on sales is immediate but temporary. Evaluated at the mean value of 0.25, the rate of sales falls by 2.43 percent already within two months and remains at about that level for around a year before reverting back to the pre-shock level. During this period of lower market activity prices gradually adjust towards the new equilibrium. It takes three months until the price decrease is large enough to be statistically significant. After six months the price is down by 2.03 percent and it continues to decrease for two years until reaching a new equilibrium level about 0.41 percent below the starting position. This pattern with sales reacting before price confirms previous empirical results of Hort (2000) and Andrew and Meen (2003) and fits well with the disequilibrium search story. The impact on the rate of entry is negative (in line with the credit constraint story) but very small and far from significant.

The *unemployment shock* has essentially no impact on any variable of interest. This may seem surprising since unemployment enters with a negative sign into the first cointegrating relation. It turns out, however, that an unemployment shock has a negative impact on the interest rate - perhaps because it triggers an expansionary monetary policy. The net effect of these two countervailing influences is a negligible impact on prices as well as on the rate of sales.

Shocks to the rates of entry and sale are by definition shocks to the supply of houses on the market - positive for an entry shock and negative for a sales shock. They may reflect different underlying shocks, e.g. to demographics, tenure choice or mobility within and across markets. A sales shock may also be a shock to the matching process between buyers and sellers. Viewing the shocks as supply shocks, one would expect more entry to have a negative price impact and more sales to have a positive impact. First, looking at the own-responses, it is seen that both shocks are relatively long-lived; the responses remain significantly positive for around one year (the rate of entry) and almost two years (the rate of sales). Both shocks affect prices in the expected direction. Increasing the rate of sales by one standard deviation leads to a gradual increase in price by around 0.7 per cent, with the full effect reached after two years by which time the rate of sale is back at its original level. The magnitude of the impact of an entry shock is about the same, with opposite sign. This is consistent with entry shocks reflecting either emigration or moves from ownership to renting and sales shocks reflecting either immigration or moves from renting to owning.

Changes in the rate of sale may also reflect mobility within the owner-occupied sector. If that were the case there would be cross effects between the rate of sale and the rate of entry. If households typically purchase a new house before putting their current dwelling on the market, then a sales shock should have a positive cross-effect on the rate entry with a lag of a couple of months. This effect, however, is negative in the very short run and essentially zero after a few months.

The rates of sale and entry may also be related if there are strong thick-market effects. Then an entry of more houses onto the market would facilitate matching and lead to an increase in the rate of sale. In the model a shock to the rate of entry does have such a positive cross effect, but it only lasts one month. After a few months it turns negative, though not quite significant, despite the fact that the impact on the rate of entry stays significantly positive for about a year.

Price shocks, finally, may be interpreted as demand (or supply) shocks other than those related to interest and unemployment and those directly affecting sales and entry. Shocks to transaction prices have little or no impact on anything, including transaction prices themselves after a couple of months. Shocks to list prices, on the other hand, have a lasting effect and spread almost immediately onto sales prices with a lag of a couple of months. This suggests that information about some permanent changes in market conditions first gets incorporated into list prices and then affects sales prices with a lag corresponding to the normal time on the market. This pattern contrasts with the reaction to other shocks, which affect both prices equally. One interpretation is that list price shocks reflect local information that is not dispersed as quickly to the entire market. Finally, we note that price shocks have little or no impact on the rates of sale and entry, i.e. there is no indication of the dynamic feedback associated with the credit constraint story.

4.6.3 Variance Decompositions

The impulse response functions help us to relate the sales-price correlation to the underlying shocks. They indicate that the correlation could be driven by interest shocks as well as shocks to the rate of sale, both of which trigger price and sales to move in the same direction during the transition towards equilibrium. Price and entry shocks, on the other hand, do not give rise to such a positive correlation. The question is which of these shocks are most important. Figures 4.16 and 4.17 decompose the variations of the forecast error of the sales price and the rate of sale at different horizons into the different shocks. For the sales price, most of the variance over short horizons is due to price shocks, with list price shocks being more important than shocks to transaction prices already from three months and onwards. This confirms the conclusion that there is important information content in list prices. At a year's horizon and longer most of the sales price variance is accounted for by other shocks than price shocks. Interest shocks and entry shocks are somewhat more important than sales shocks, accounting for 32, 33 and 22 percent respectively after five years. The variance decomposition of the list price looks almost identical to that of the transaction price at horizons longer than a year. The variance decomposition for the rate of sale is illustrated in Figure 4.17. Here own shocks to the rate of sale remain dominant up to three years and continue to account for as much as 29 percent even after five years. Mortgage rate shocks account for almost as much (28 percent after five years), while entry shocks only account for 12 percent after five years.

4.7 Understanding the Price-Quantity Correlation

We are now in a position to explain the sources of the correlation between price and quantity in the Dutch housing market. Recall that this comovement mainly stems from a strong correlation between variations in price and the rate of sale, whereas the correlation between sales and the rate of entry is low. This is *prima facie* evidence that the price-quantity correlation reflects aspects of the price formation and micro structure of housing markets rather than simply changes in the balance between supply and demand. Based on the estimated VEC-model we may draw sharper conclusions. If the dynamics of price and quantity were driven by variations in the tightness of credit constraints, then we would expect to see shocks to fundamentals affecting prices immediately and having a secondary impact on the rate of entry of new houses for sale. Since the sellers of houses would also appear as buyers (with some lag) we would not expect to see much impact on the rate of sale. This is the opposite of what our estimated impulse response functions indicate: an interest shock has a gradually increasing effect on price, an immediate but temporary effect on sales and little effect on entry. We conclude that the credit constraint story does not explain the correlation between price and quantity observed in the Netherlands.

The Dutch evidence is much more consistent with a story of a gradual adjustment of expectations to new information about fundamentals. If buyers and sellers did not fully account for the impact of a shock to fundamentals on market prices, then one would expect to see a gradual price change, but an immediate change in the rate of sale. This is what the impulse response functions indicate. This is also in line with the findings of the studies of Hort (2000), which also looks at interest rate shocks, and Andrew and Meen (2003), which looks at a more general representation of price fundamentals. Both of these papers are limited to studying total sales, however, and do not distinguish between the rates of sale and entry. In this respect, our paper provides sharper evidence about the underlying mechanism.

A number of papers have developed equilibrium search models of the housing market.

A common theme in these models is that thicker and more liquid markets are associated with higher prices and a higher rate of sale (shorter time on the market). This would imply that shocks to the rate of entry, bringing more houses onto the market, would lead to higher prices and a higher rate of sale. We find just the opposite. This should not be taken as strong evidence against the equilibrium search models as they are developed for closed housing markets, where anybody who offers his house for sale also appears on the other side of the market looking for a house to buy. A reasonable interpretation of our model is that a shock to the rate of entry largely is a supply shock reflecting moves into or out of the Dutch ownership market, due to migration or switches between owning and renting.

We believe that our results tell a consistent story, but they are of course limited to a particular housing market and a particular time period. Compared to many other markets, the Dutch housing market was relatively balanced throughout the entire period. In particular, there was no period of falling nominal prices, a situation where the credit constraint story may be most relevant. Further, the Dutch credit market offers easier access to mortgage borrowing than most other credit markets. For both these reasons similar studies for other countries and other time periods would be needed before drawing more general conclusions.

Table 4.1: *Augmented Dickey-Fuller Stationarity Tests*

	u	i	e	S	lp	tp
Test statistic	-1.77	-2.50	-3.87	-1.19	-0.54	-0.36

Note.–Intercept and linear trend included. Monthly dummies included for all variables except the interest rate. Two lagged differences. n = 258. Critical values: 1% = 3.96, 5% = 3.43, 10% = 3.13. See Said and Dickey (1984).

Table 4.2: *Johansen Trace Test*

Rank	*LR*	*p-value*
0	184.38	0.0000
1	91.53	0.0000
2	44.43	0.0332
3	11.26	0.8554
4	4.91	0.6159
5	184.38	0.0000

Note.–LR denotes the log likelihood ratio of the null hypothesis indicated by the rank number against the alternative of a larger rank. Model (1) with p=3. n = 258. See Johansen (1996).

Table 4.3: *The estimated VECM*

α	Δu	Δi	Δe	Δs	Δlp	Δtp	
α'_1	-0.037	-0.233	-0.000	-0.068	-0.017	-0.015	
	(-1.103)	(-3.395)	(-0.787)	(-3.152)	(-2.472)	(-2.571)	
α'_2	0.556	-0.980	0.004	-0.305	-0.077	0.377	
	(1.488)	(-1.290)	(1.174)	(-1.283)	(-1.029)	(5.651)	
α'_3	0.036	-0.017	0.000	-0.035	0.015	0.028	
	(1.748)	(-0.396)	(1.485)	(-2.684)	(3.629)	(7.671)	
α'_4	-2.976	-10.158	-0.169	-12.733	-3.720	-3.518	
	(-0.588)	(-0.988)	(-3.486)	(-3.951)	(-3.683)	(-3.889)	
β	u	i	e	S	lp	tp	T
β'_1	0.232	0.264				1	-0.002
	(7.920)	(6.875)					(-7.989)
β'_2	0.011	0.017			1	-1	0.0002
	(5.638)	(3.463)					(7.517)
β'_3		-0.331		2.150		1	-0.006
		(-4.573)		(17.458)			(-13.673)
β'_4			1				
	Δu	Δi	Δe	Δs	Δlp	Δtp	
Residual standard error	0.023	0.048	0.00022	0.015	0.005	0.004	
Cross-correlations							
Δu	1.000						
Δi	-0.027	1.000					
Δe	-0.008	-0.057	1.000				
Δs	-0.037	-0.100	0.470	1.000			
Δlp	-0.081	0.074	-0.087	-0.067	1.000		
Δtp	-0.111	0.036	-0.074	0.139	0.395	1.000	

Note.–The effective sample is from January 1986 to June 2007. 258 months. The number of lags p is 3. The identification restrictions β are elements of being -1, 0 and 1. Estimates of μ, Γ_i and Φ are not included.

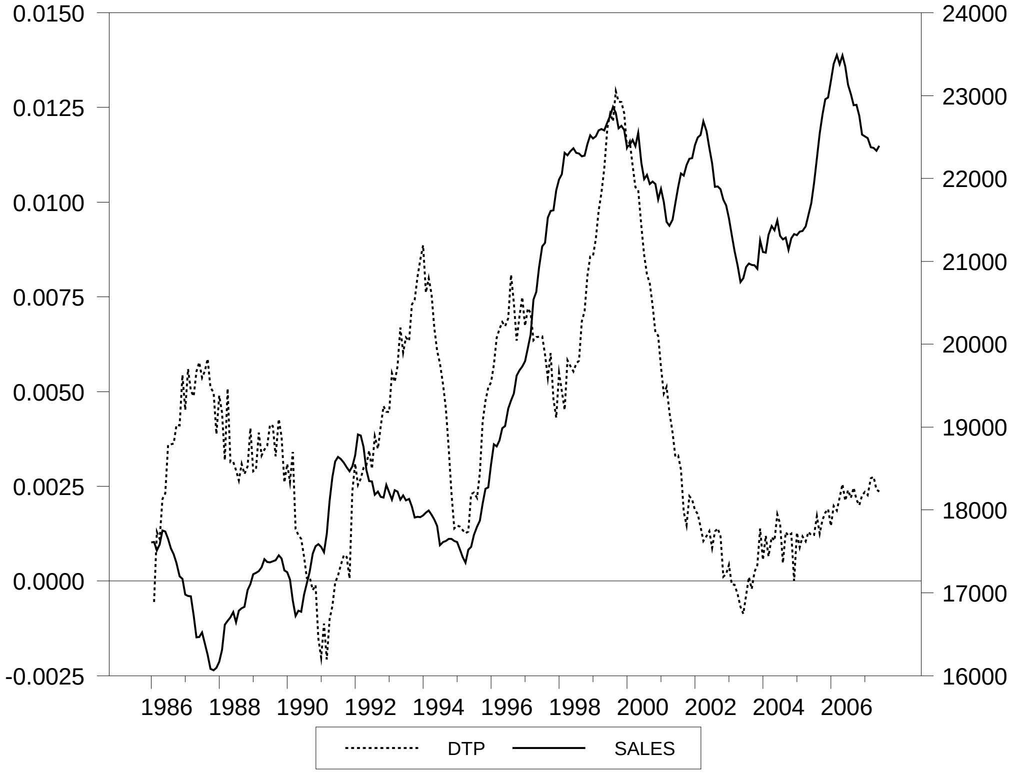

Figure 4.1: *Number of dwellings sold and the rate of real price change. DTP is the rate of price change expressed as the 12 month average of the monthly change in the transaction price index. Sales is the 12 month average of the number of sold houses where the number of sold houses are corrected for the NVM market share.*

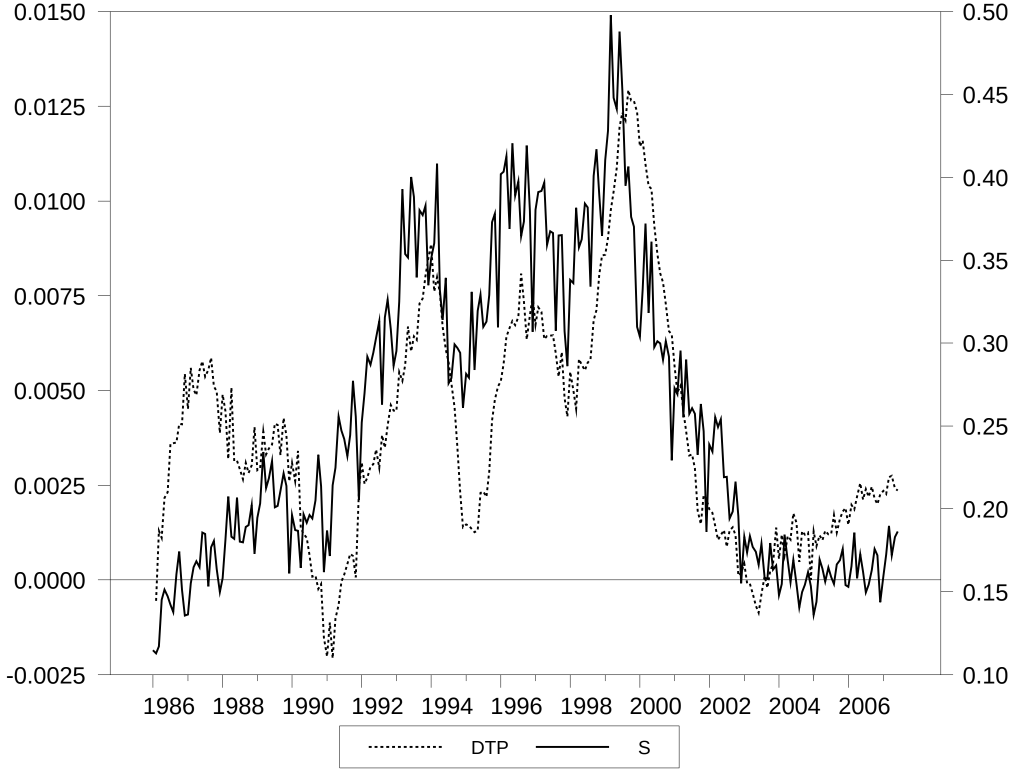

Figure 4.2: *Percentage transaction price change (12 month moving average) and rate of sale. DTP is the rate of price change expressed as the 12 month average of the monthly change in the transaction price index. S is the rate of sale expressed as the number of houses sold in the current month divided by the number of houses on the market at the start of the month.*

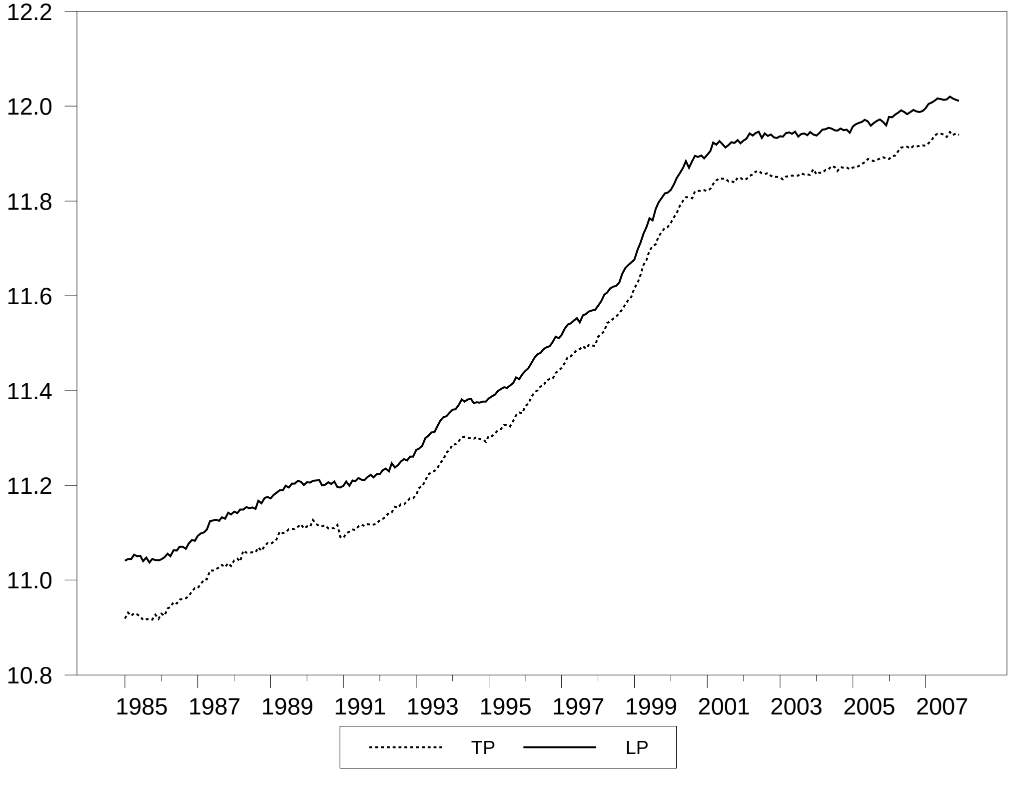

Figure 4.3: *Indexes for sales price and list price, CPI deflated, logs. TP is the transaction price index and LP is the list price index. Both indices are CPI deflated and in logs.*

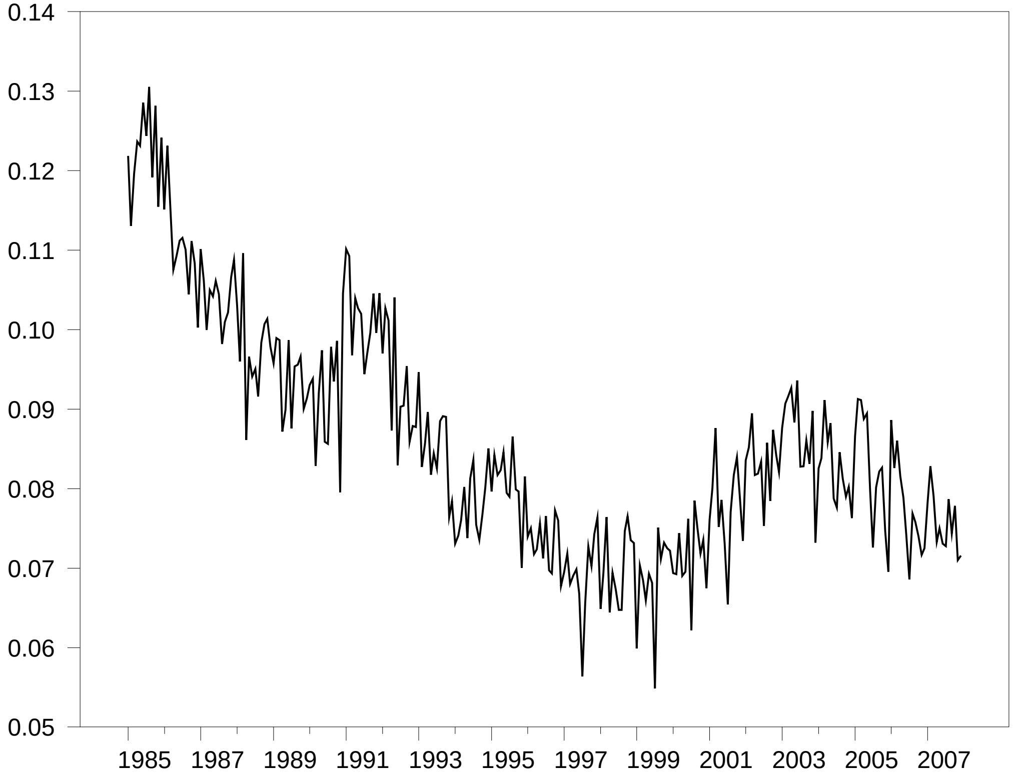

Figure 4.4: *Discount of sales price relative to list price (log difference)*

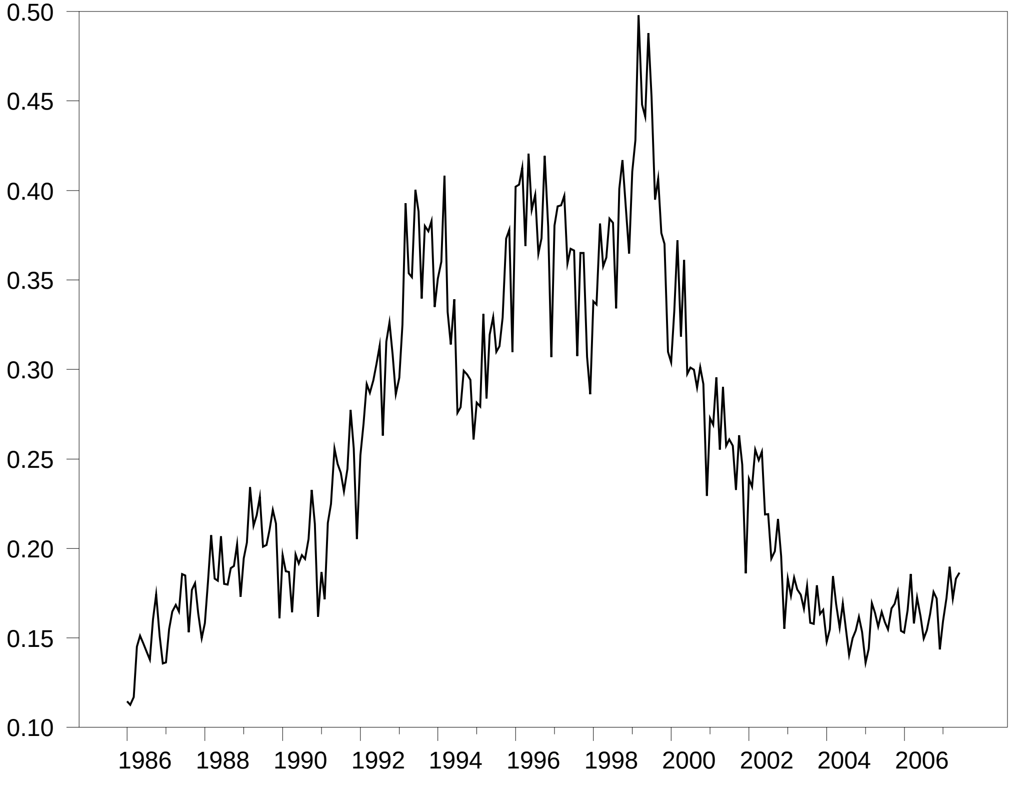

Figure 4.5: *Rate of sale. The rate of sale is expressed as the number of houses sold in the current month divided by the number of houses on the market at the start of the month.*

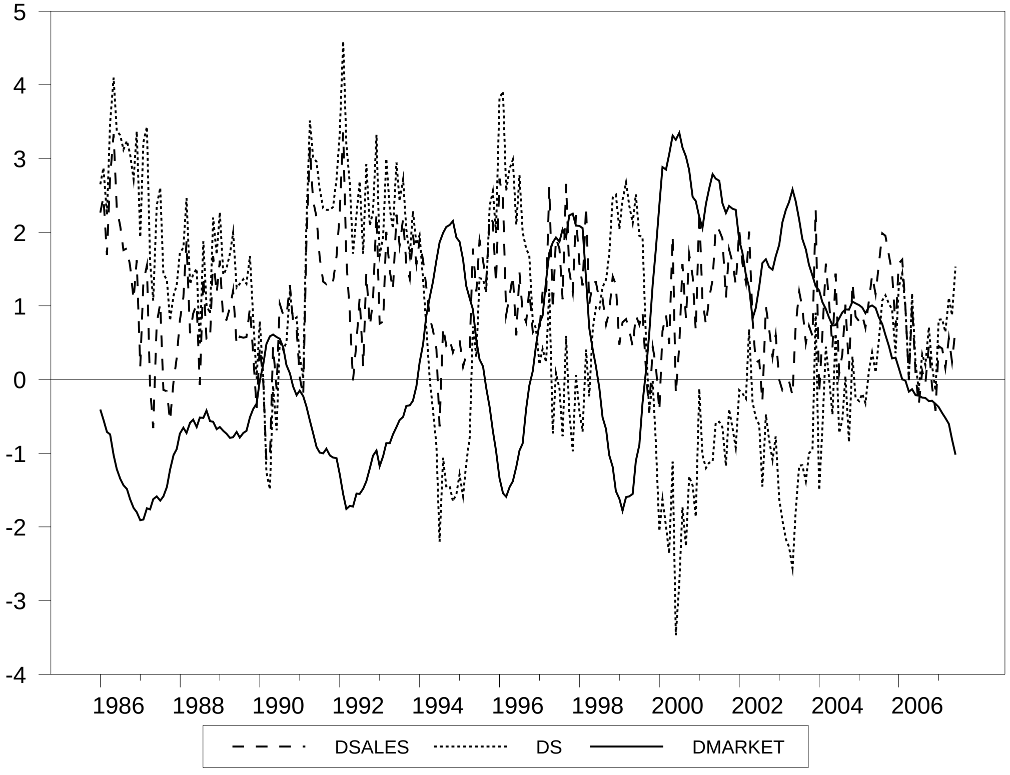

Figure 4.6: *Number of houses sold, number of houses for sale and rate of sale, percentage changes. DSALES is the 12 month average of the change in the number of houses sold in each month, DS is the 12 month average of the change in the rate of sale, DMARKET is the 12 month average of the monthly change in the number of houses on the market.*

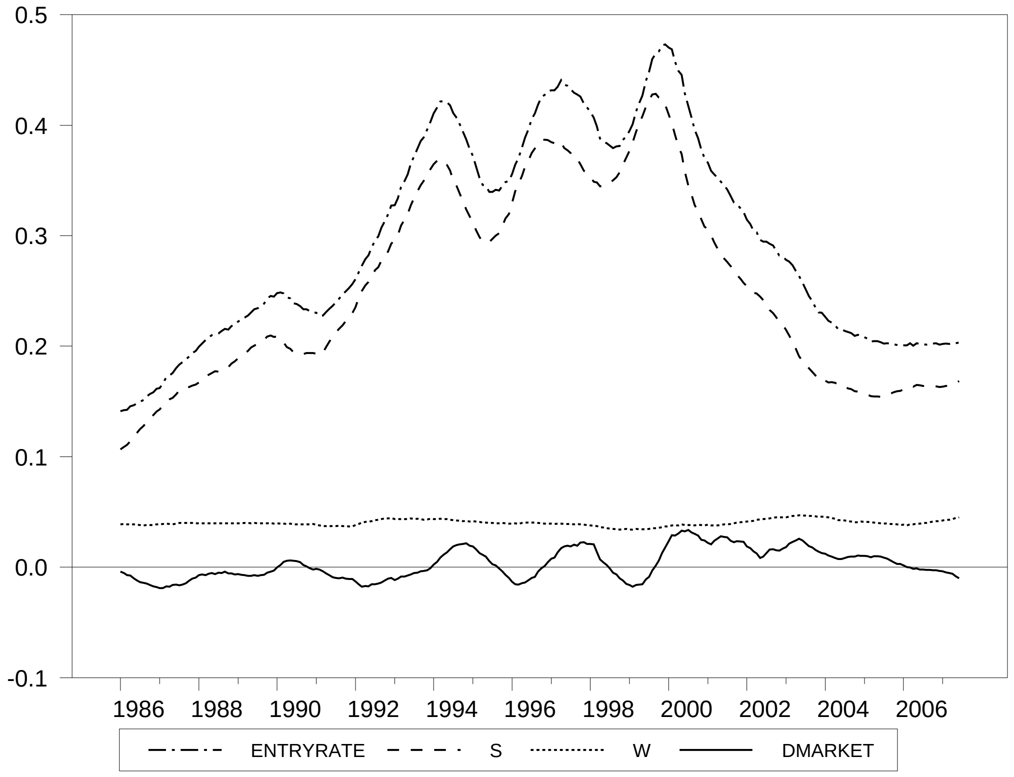

Figure 4.7: *Rates of entry, sale and withdrawal (12 month moving averages). ENTRYRATE is expressed as the number of houses which entered the market in the current month divided by the number of houses on the market at the start of the month, S is the rate of sale and is expressed as the number of houses which sold in the current month divided by the number of houses on the market at the start of the month, W is the rate of withdrawal and is expressed as the number of houses which were withdrawn from the market in the current month divided by the number of houses on the market at the start of the month, DMARKET is the monthly change in the number of houses on the market. All series are 12 month averages.*

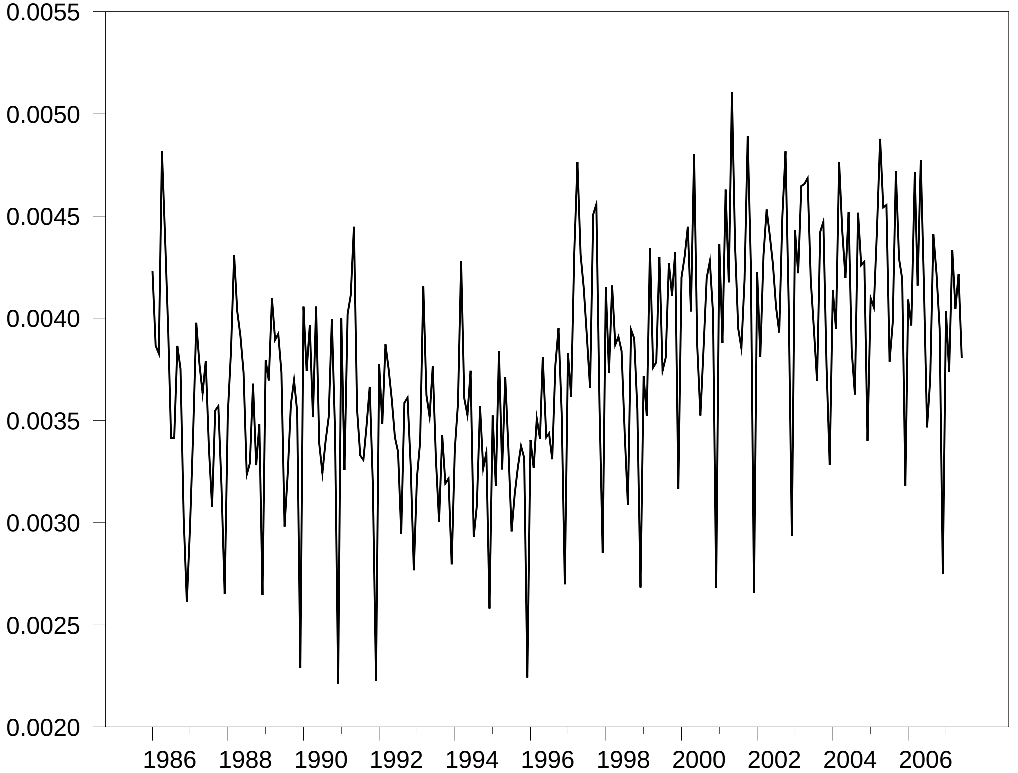

Figure 4.8: *Rate of entry (number of new houses for sale divided by total stock of houses). The rate of entry is expressed as the number of houses which entered the market in the current month divided by the total housing stock at the start of the month.*

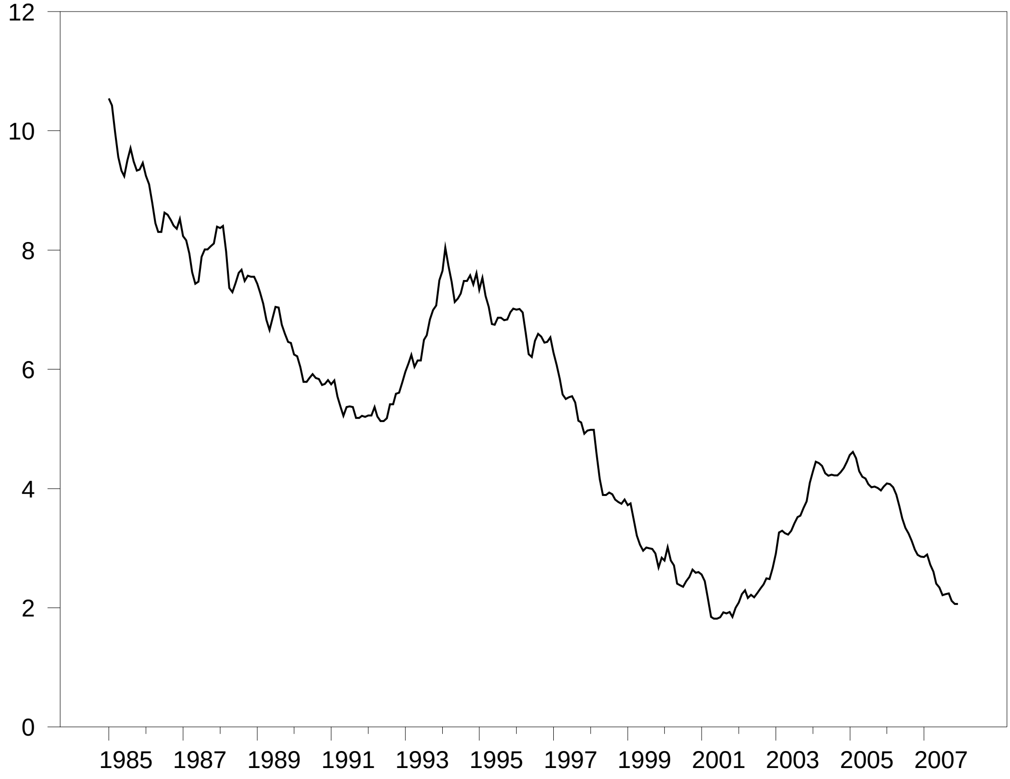

Figure 4.9: *Unemployment rate, percent*

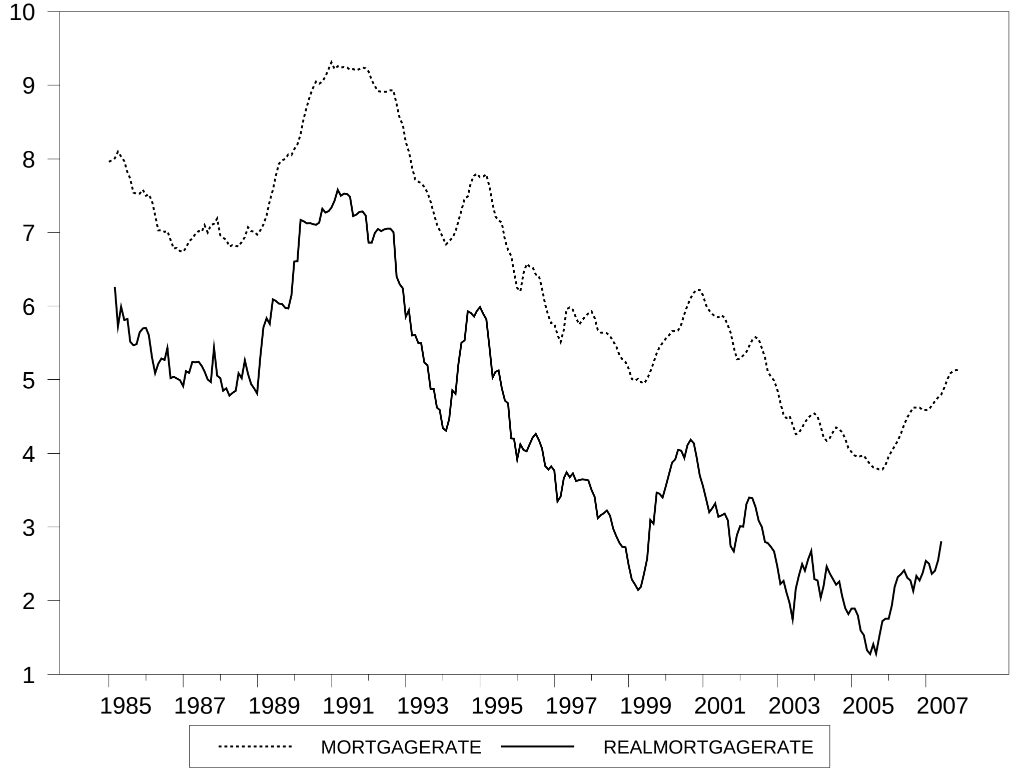

Figure 4.10: *Mortgage interest rate, nominal and real, percent. MORTGAGERATE is the mean nominal interest rate on all 5 year mortgages issued in the current month. REAL-MORGAGERATE is equal to MORTGAGERATE minus a measure of 5 year inflation expectations. Inflation expectations are constructed based on an ARMA(7,7) model of CPI inflation.*

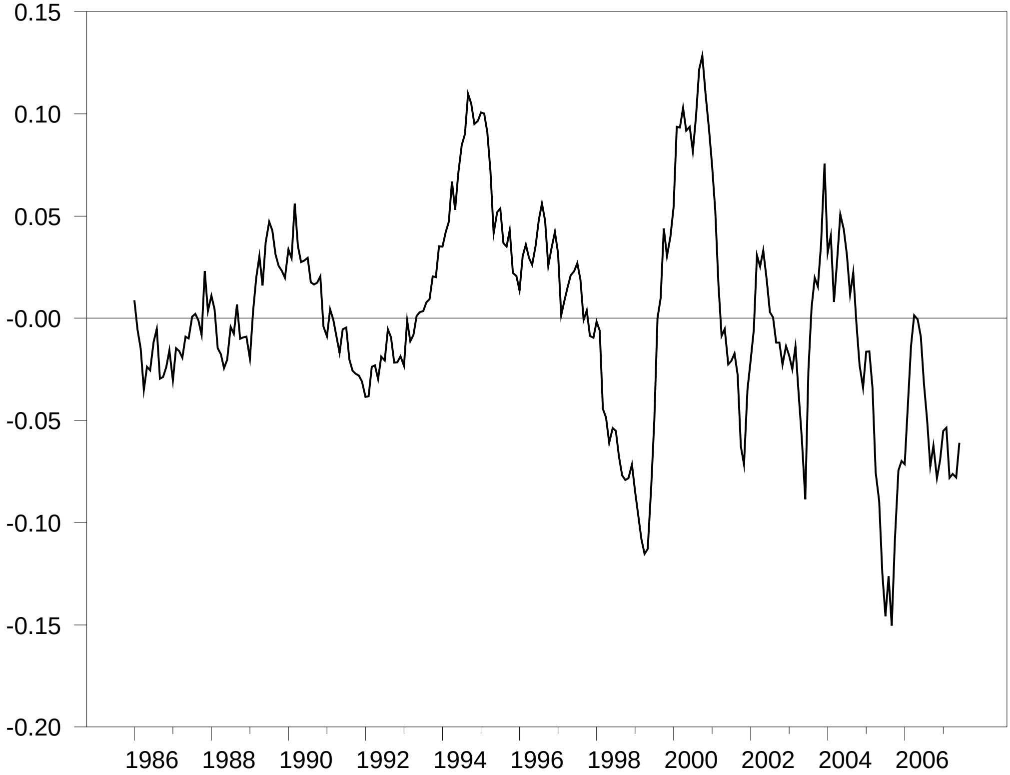

Figure 4.11: *The residual from cointegrating relation 1*

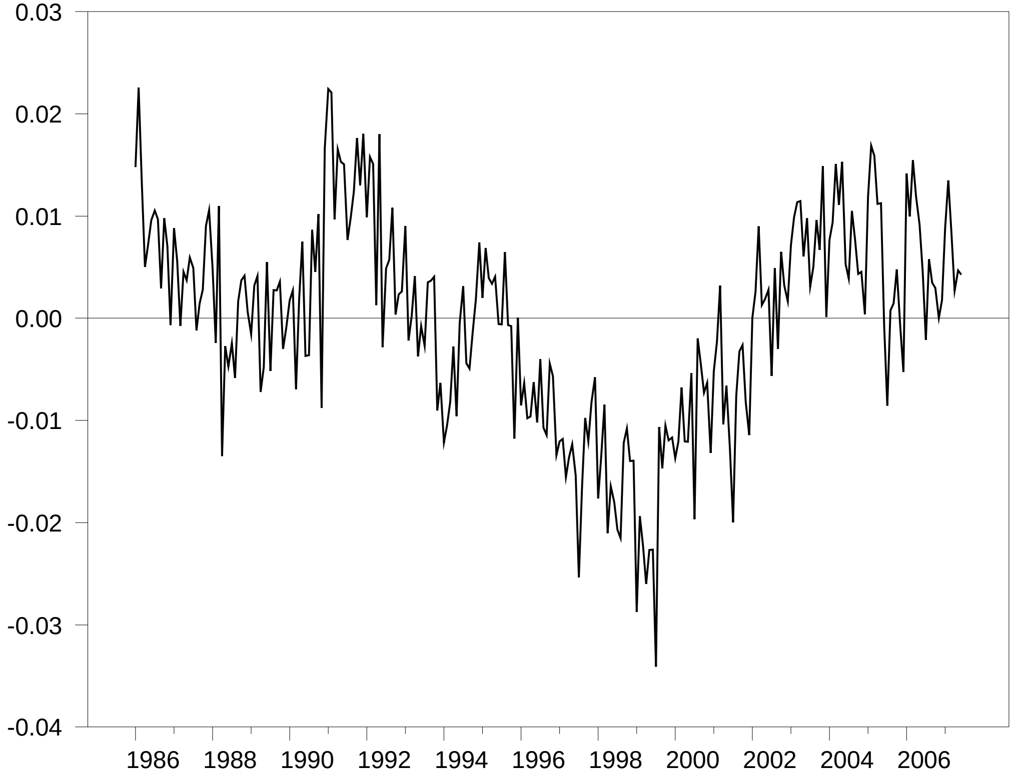

Figure 4.12: *The residual from cointegrating relation 2*

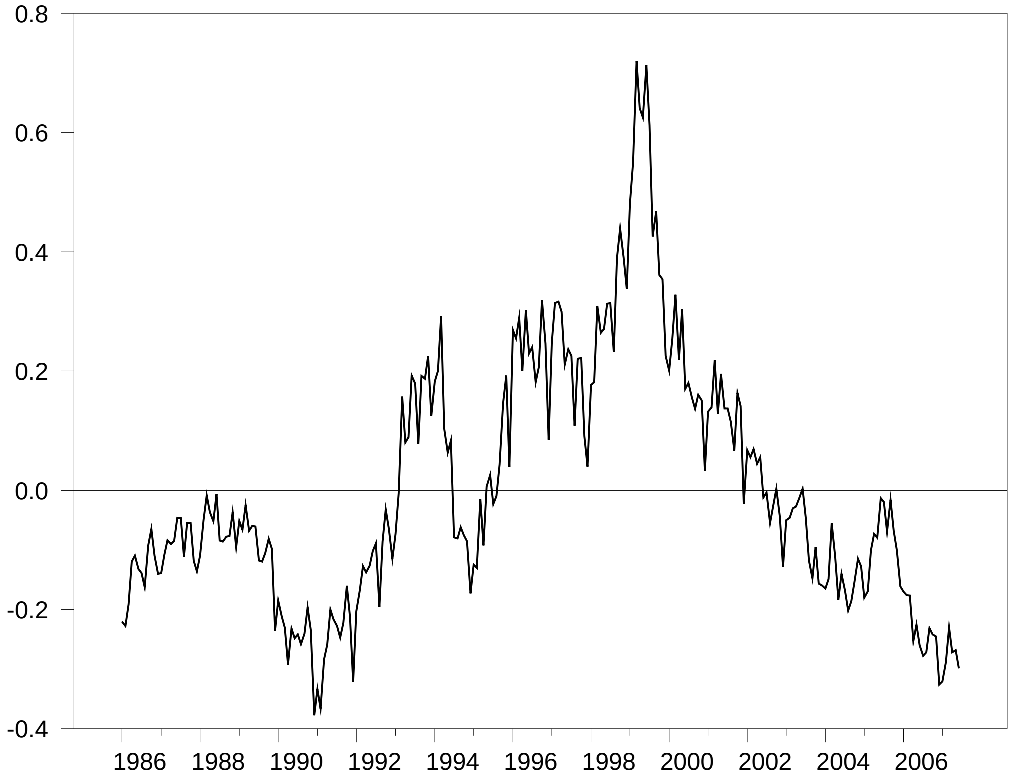

Figure 4.13: *The residual from cointegrating relation 3*

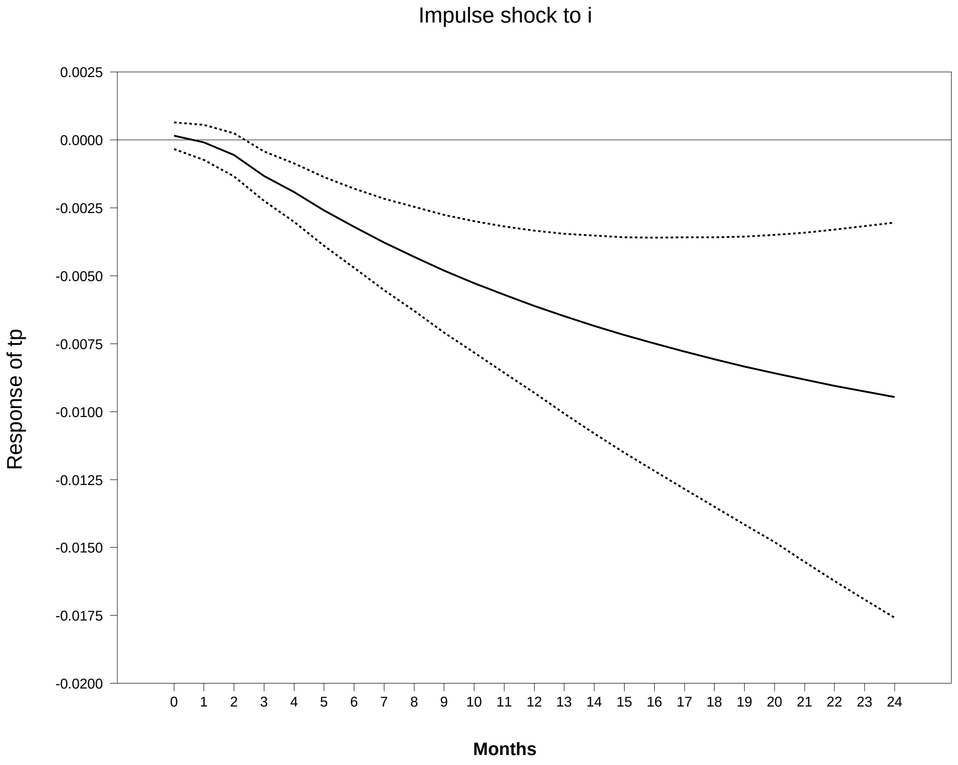

Figure 4.14: *Response of transaction price to an interest shock with 90 percent confidence intervals*

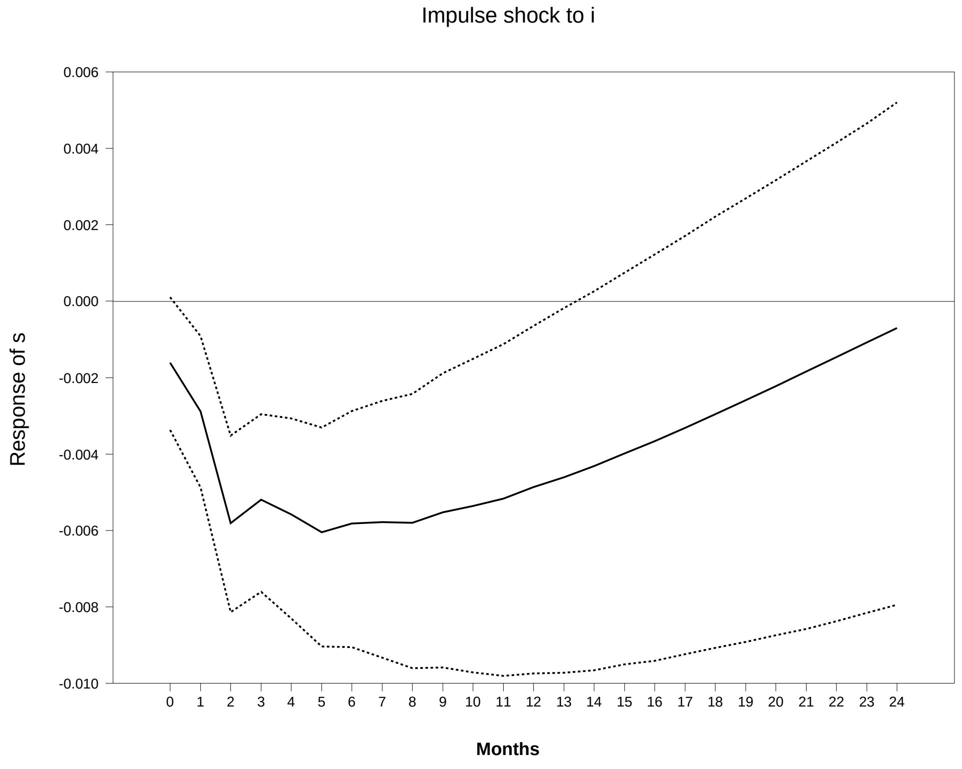

Figure 4.15: *Response of rate of sale to an interest shock with 90 percent confidence intervals*

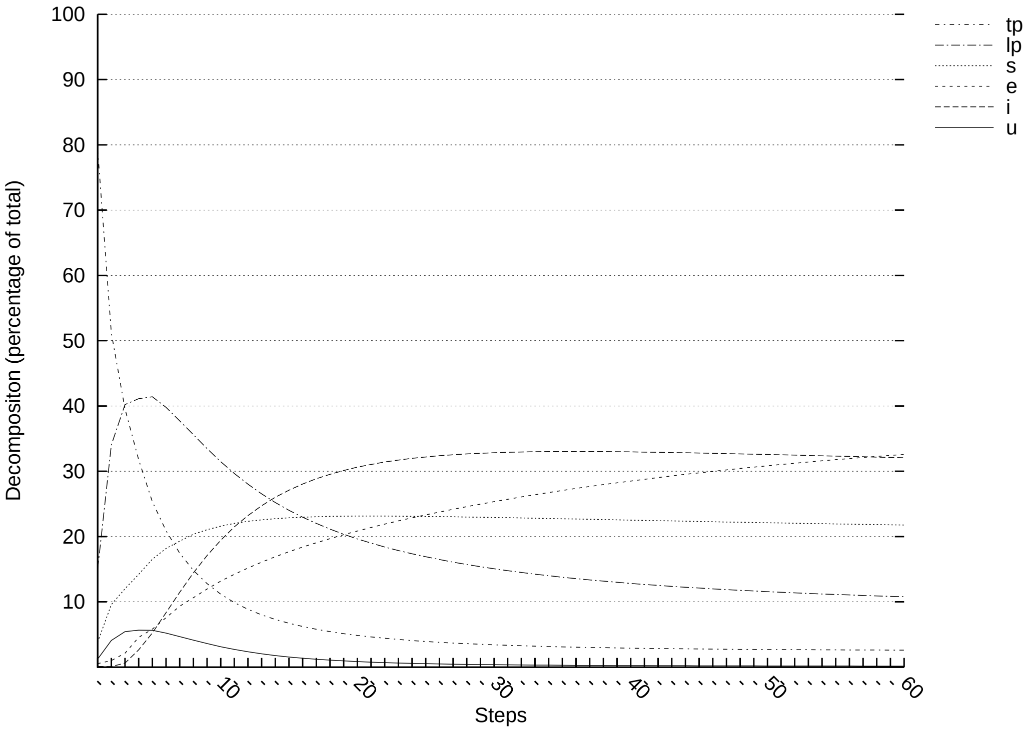

Figure 4.16: *Decomposition of the forecast-error variance in the transaction price index*

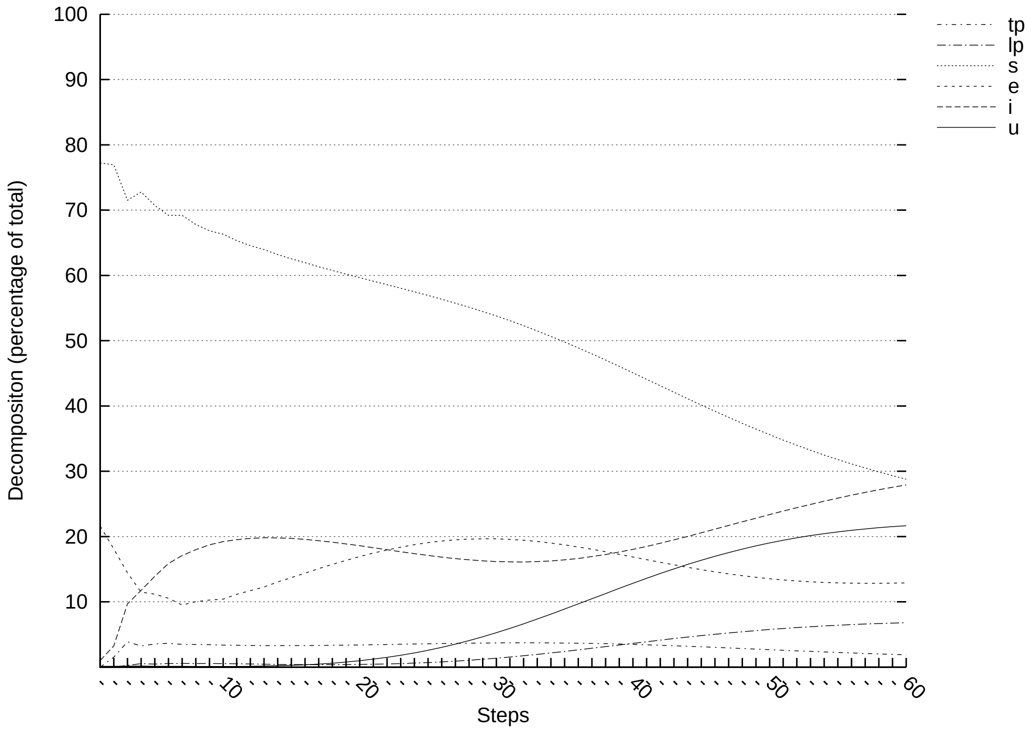

Figure 4.17: *Decomposition of the forecast-error variance in the rate of sale*

4.8 Appendix: Price index estimation

We estimate indexes for transactions and list prices based on hedonic regressions of the type

$$\log P_{itm} = x'_{itm}\beta + \varepsilon_{itm} \tag{4.5}$$

where P_{itm} denotes the price of house i sold in month m of year t, x is a vector of characteristics including dummy variables indicating the month of sale. The β vector contains marginal prices of the characteristics and log price indexes corresponding to the monthly dummies. We estimate separate equations year by year and chain them as follows. We compute the one-year return r for a house with mean characteristics $\overline{x}_{tm}$ as follows. The year-over-year-return $\overline{r}_{tm}$ of the price index in any year t and calendar month m is calculated as

$$r_t m = (\overline{x}'_{t-1,m}\hat{\beta}_t) - (\overline{x}'_{t-1,m}\hat{\beta}_{t-1}) \tag{4.6}$$

The mean value $\overline{x}_{t-1,m}$ is based on the set of all sold houses in year *t-1*. We use this same set for both the transaction price index and the list price index so return differences between the transaction price index and the list price index can only be attributed to price differences and not to differences in characteristics. The log of the nominal price index I_{tm} is then given by

$$I_{tm} = \overline{x}'_{0,m}\hat{\beta}_0 + \sum_{\tau=1}^{t} r_{\tau m} \tag{4.7}$$

As an example, Table 4.4 presents the hedonic regression for 1998 sales prices. Table 4.7 gives summary statistics for all regressions.

Table 4.4: *Hedonic regression of the log of transaction price on characteristics for 1998 (I)*

	Coeff.	*Std.Error*
Constant	9.678	0.217
Log floor size	0.145	0.040
Log floor size squared	0.062	0.004
Log lot size	-0.039	0.001
Log lot size squared	0.005	0.000
Number rooms	0.018	0.001
Typehouse2	0.127	0.005
Typehouse3	0.043	0.002
Typehouse4	0.148	0.003
Typehouse5	0.357	0.003
Typeapp1	-0.048	0.005
Typeapp2	-0.102	0.005
Typeapp3	-0.120	0.006
Typeapp4	-0.088	0.005
Typeapp5	-0.104	0.005
Typeapp6	-0.266	0.018
Typeapp7	0.032	0.017
Lift	0.049	0.003
Building age unknown	0.036	0.028
Built 1500-1905	0.057	0.004
Built 1906-1930	-0.023	0.003
Built 1931-1944	-0.021	0.003
Built 1945-1959	-0.024	0.003
Built 1960-1970	-0.078	0.002
Built 1971-1980	-0.058	0.002
Built 1991-2000	0.072	0.003

Table 4.5: *Hedonic regression of the log of transaction price on characteristics for 1998 (II)*

	Coeff.	*Std.Error*
Parking2	0.067	0.003
Parking3	0.073	0.004
Parking4	0.120	0.002
Parking6	0.120	0.005
Parking8	0.168	0.005
Garden0	-0.021	0.003
Garden1	-0.016	0.003
Garden2	-0.014	0.004
Garden3	-0.021	0.003
Garden5	0.000	0.003
Garden6	0.005	0.003
Garden7	-0.006	0.003
Garden8	-0.006	0.004
Insulation	-0.011	0.002
No heating	-0.438	0.195
Gas or coal heater	-0.500	0.195
Other central heating	-0.41	0.195
Quiet road	0.014	0.002
Ground lease	-0.066	0.003
Internal maintenance	0.024	0.001
Exterior maintenance	0.015	0.001
R^2 adjusted		0.812
Standard error of estimate		0.195
Observations		83485

Table 4.6: *Definitions for table 4.4 and 4.5*

House Type	
Typehouse1	1 if row house
Typehouse2	1 if back-to-back housing
Typehouse3	1 if corner house (hoekwoning)
Typehouse4	1 if semi-detached house
Typehouse5	1 if detached house
Apartment Type	
Typeapp1	1 if ground-level apartment
Typeapp2	1 if top-level apartment
Typeapp3	1 if maisonette
Typeapp4	1 if staircase-access flat
Typeapp5	1 if gallery flat
Typeapp6	1 if old-age housing
Typeapp7	1 if two-floor apartment
Parking	
Parking0	1 if no parking place
Parking2	1 if outdoor parking place
Parking3	1 if carport and garage
Parking4	1 if carport but no garage
Parking6	1 if garage but no carport
Parking8	1 if garage for more than one car
Garden	
Garden0	1 if no garden
Garden1	1 if garden facing north
Garden2	1 if garden facing north-east
Garden3	1 if garden facing east
Garden4	1 if garden facing south-east
Garden5	1 if garden facing south
Garden6	1 if garden facing south-west
Garden7	1 if garden facing west
Garden8	1 if garden facing north-west
Maintenance	
Interior and exterior maintenance are assessed on a scale from 1 to 9	
Location	
76 regional dummies are included	

Table 4.7: *Summary Statistics, All Hedonic Regressions*

	TransactionPrice			*ListPrice*		
Year	R_2 *Adj.*	*Std. err. of estimate*	*Obs.*	R_2 *Adj.*	*Std. err. of estimate*	*Obs.*
1985	0.812	0.197	18640	0.799	0.216	25210
1986	0.814	0.191	23739	0.803	0.208	28300
1987	0.813	0.199	24102	0.802	0.216	27926
1988	0.807	0.201	25141	0.796	0.216	29291
1989	0.807	0.204	27134	0.801	0.216	30235
1990	0.811	0.203	25398	0.802	0.216	29656
1991	0.814	0.197	29991	0.809	0.211	33654
1992	0.813	0.191	33527	0.807	0.208	36610
1993	0.815	0.180	38052	0.808	0.197	41588
1994	0.824	0.176	37181	0.810	0.192	41380
1995	0.826	0.177	51991	0.817	0.193	59223
1996	0.828	0.177	63683	0.826	0.186	69499
1997	0.827	0.181	73497	0.806	0.201	82621
1998	0.812	0.195	83485	0.807	0.207	89555
1999	0.806	0.211	90690	0.776	0.246	100115
2000	0.806	0.218	92076	0.770	0.260	106265
2001	0.805	0.210	101148	0.786	0.247	112126
2002	0.809	0.199	94873	0.798	0.238	123973
2003	0.814	0.194	96651	0.804	0.226	143185
2004	0.810	0.199	124173	0.790	0.232	167671
2005	0.809	0.198	141971	0.800	0.223	176290
2006	0.813	0.203	144303	0.787	0.238	175441
2007	0.813	0.207	144450	0.766	0.253	160818
Average	0.813	0.196	-	0.799	0.219	-
St.dev	0.007	0.012	-	0.014	0.020	-
Total	-	-	1585897	-	-	1890633

4.9 Appendix: Inferring the market rate of entry

The sales covered by our data include only properties sold by NVM. Since the market share of NVM has varied over the years this may bias our measure of the rate of entry. To account for this we first measure the NVM market share. Statistics on the total number of sales in the Netherlands only exist from 1993 through the Dutch land registry. the Kadaster. In order to backcast sales from 1985 we run an OLS regression on data from 1993:1-2005:12 data for log(#MarketSales) against log(real GDP) and monthly dummies. The results are given in table 4.8.

Table 4.8: *Regression Coefficients*

Variable	*Coefficient*	*Std.Error*
LOG(REALGDP)	0.975430	0.056107
D2	0.107217	0.031324
D3	0.283353	0.031324
D4	0.271763	0.031324
D5	0.328597	0.031324
D6	0.306609	0.031324
D7	0.461724	0.031324
D8	0.379500	0.031324
D9	0.311551	0.031324
D10	0.364873	0.031324
D11	0.333500	0.031324
D12	0.679455	0.031324
C	-4.524174	0.694360
Adjusted R-squared	0.854919	
S.E. of regression	0.079860	
Durbin-Watson stat	1.366961	

The Kadaster sales data has a seasonal pattern not found in the NVM. There is also a time lag between the NVM information dated at the time of signing the contract and the subsequent register date in the Kadaster. To take this into account we measure the NVM market share by using 12 month moving averages lagging the NVM observations three months relative to the Kadaster numbers. Denoting the NVM market share of sales by α_t we have

$$\alpha_t = \sum_{i=0}^{11} \#NVMMarketSales_{t-1} / \sum_{i=0}^{11} \#NVMMarketSales_{t+3-i}$$

We have data on entry and exit of NVM properties. We also know the total number of sales and can calculate the NVM market share (in terms of sales). We want to use these data to infer entry and exit rates on the market level.

Next we want to measure the market share of entry. To simplify, and since we do not have information that would justify another assumption, we assume that α also applies to the number of houses on the market. We assume that the rates of entry, sale and withdrawal are the same for all brokers, implying that the increasing market share of NVM reflects an increased number of members, not that NVM brokers are different.

Defining the market rate of entry as

$$e_t = Entry_t/Stock_t$$

The observed amount of entry (superscript N to denote NVM) can then be expressed as

$$Entry_t^N = e_t Stock_t^N + e_\delta Stock_t^N$$

where $e_t^\Delta = \frac{\alpha_t^e - \alpha_{t-1}^e}{\alpha_{t-1}^e}$

The conclusion is that we should adjust the observed entry rate by deducting the relative increase of NVM market share. Furthermore. we do not observe the NVM market share of properties entering the market. We approximate this by the lagged market share of sold dwellings.

$$\alpha_t^e = \alpha_{t-x_t}$$

where x_t is the average time till sale in month t (measured in months) rounded to the nearest integer.

4.10 Appendix: Impulse Response Functions

In this appendix we present graphs of the response of the variables of the system to one standard deviation Choleski orthogonalized shocks, according to four different orderings as defined in the main text. Each column represents a shock and each row an endogenous variable. Included are 90% confidence intervals.

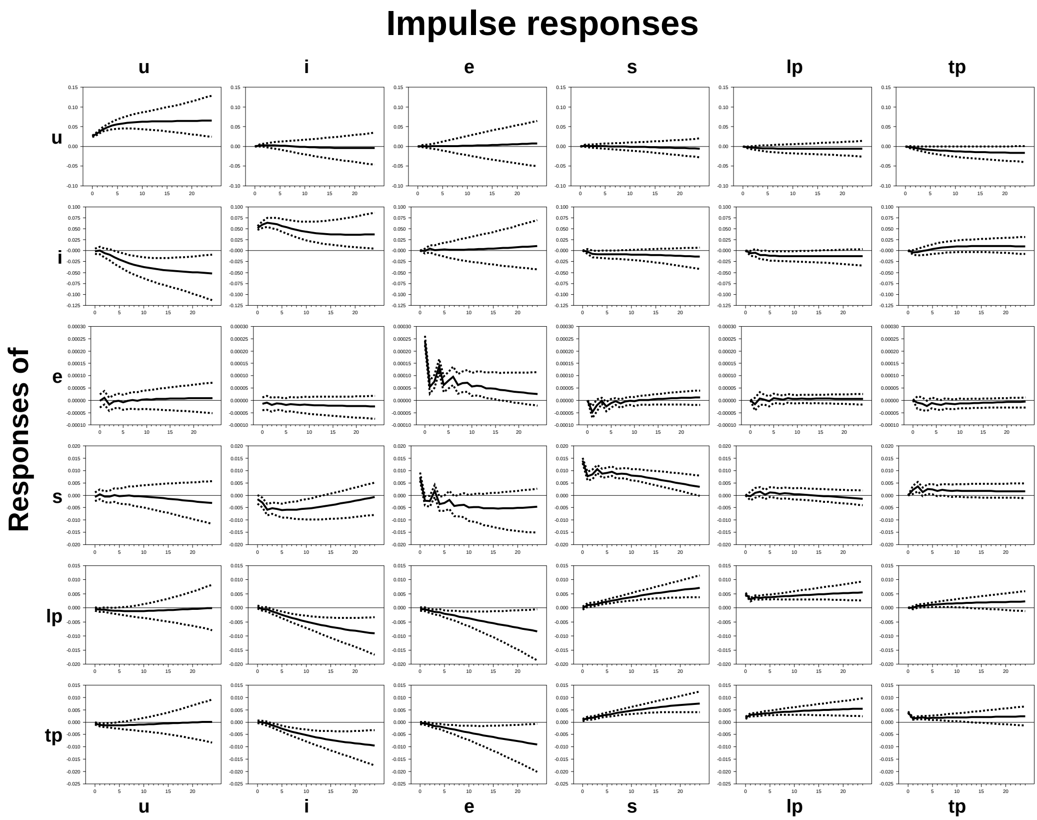

Figure 4.18: *Impulse responses. Ordering 1*

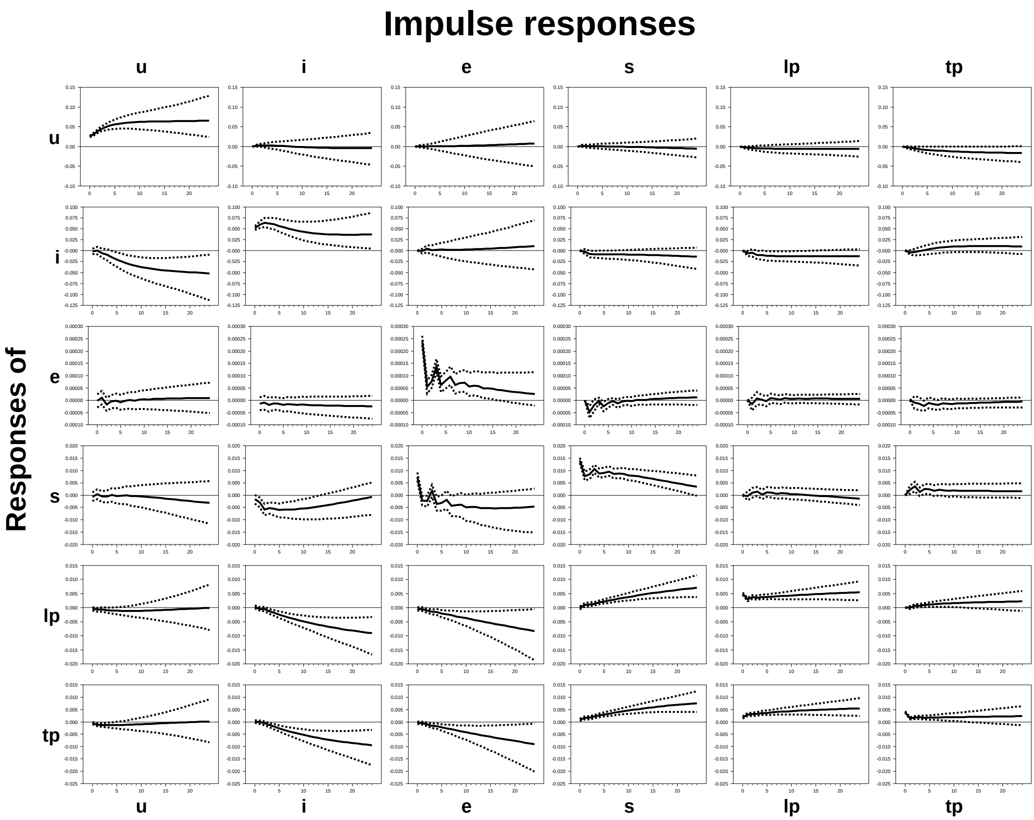

Figure 4.19: *Impulse responses. Ordering 2*

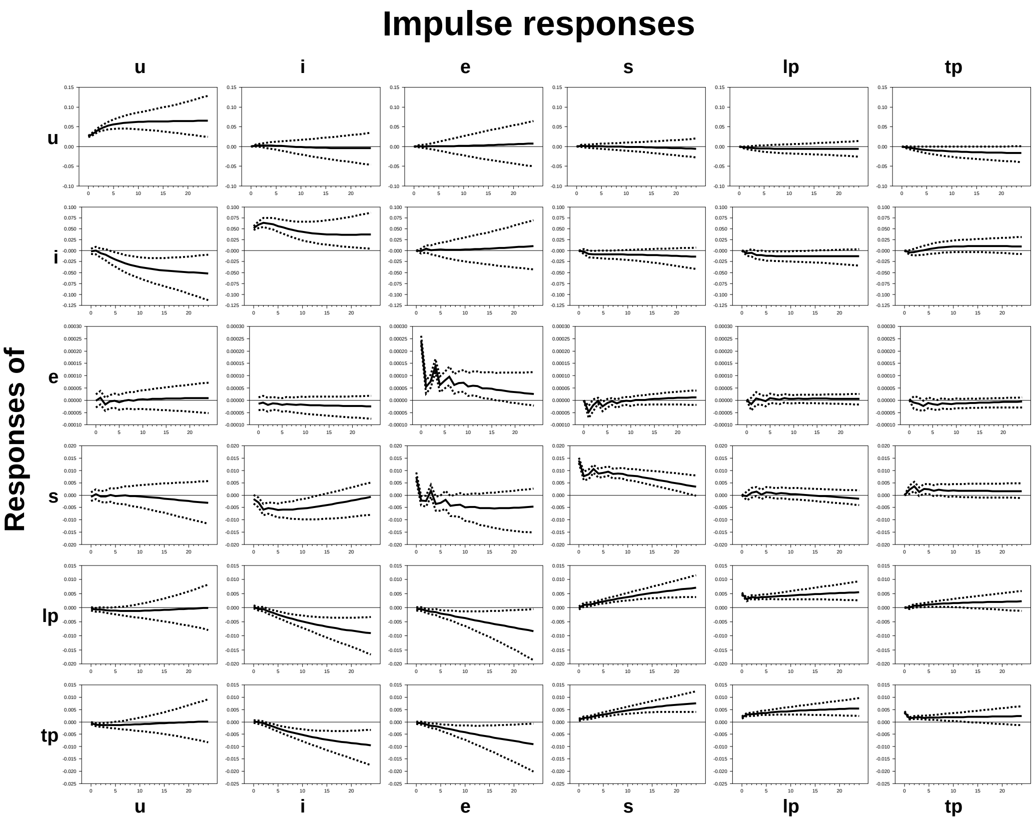

Figure 4.20: *Impulse responses. Ordering 3*

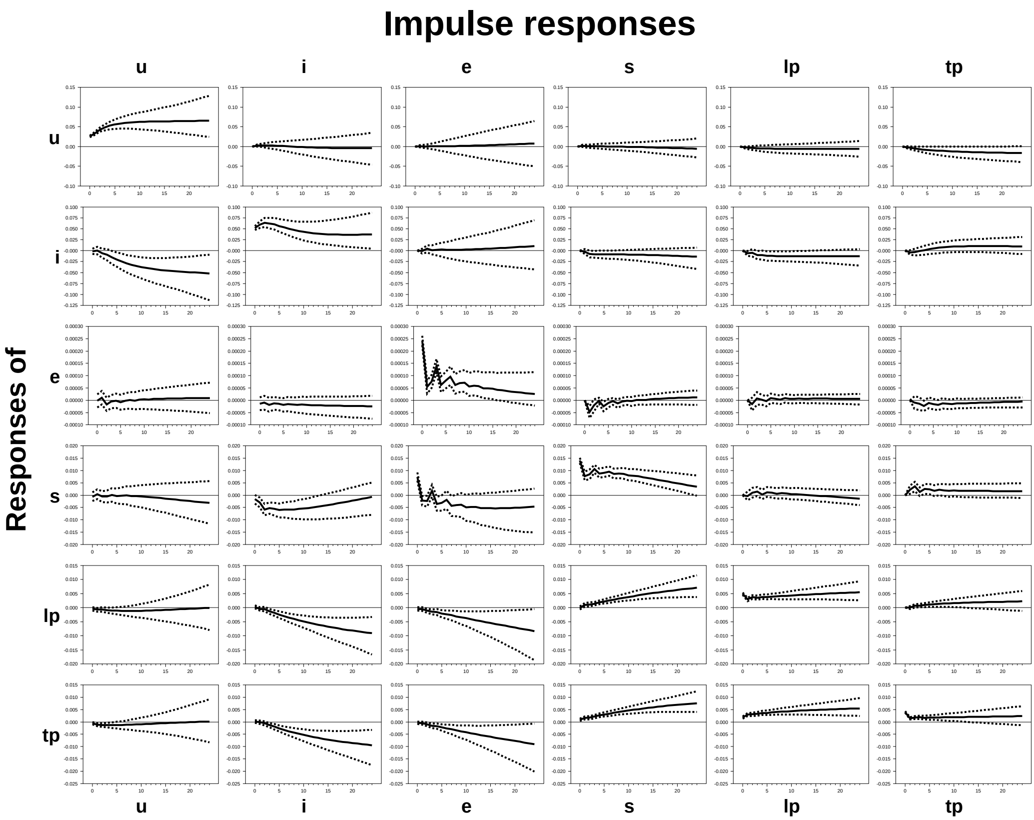

Figure 4.21: *Impulse responses. Ordering 4*

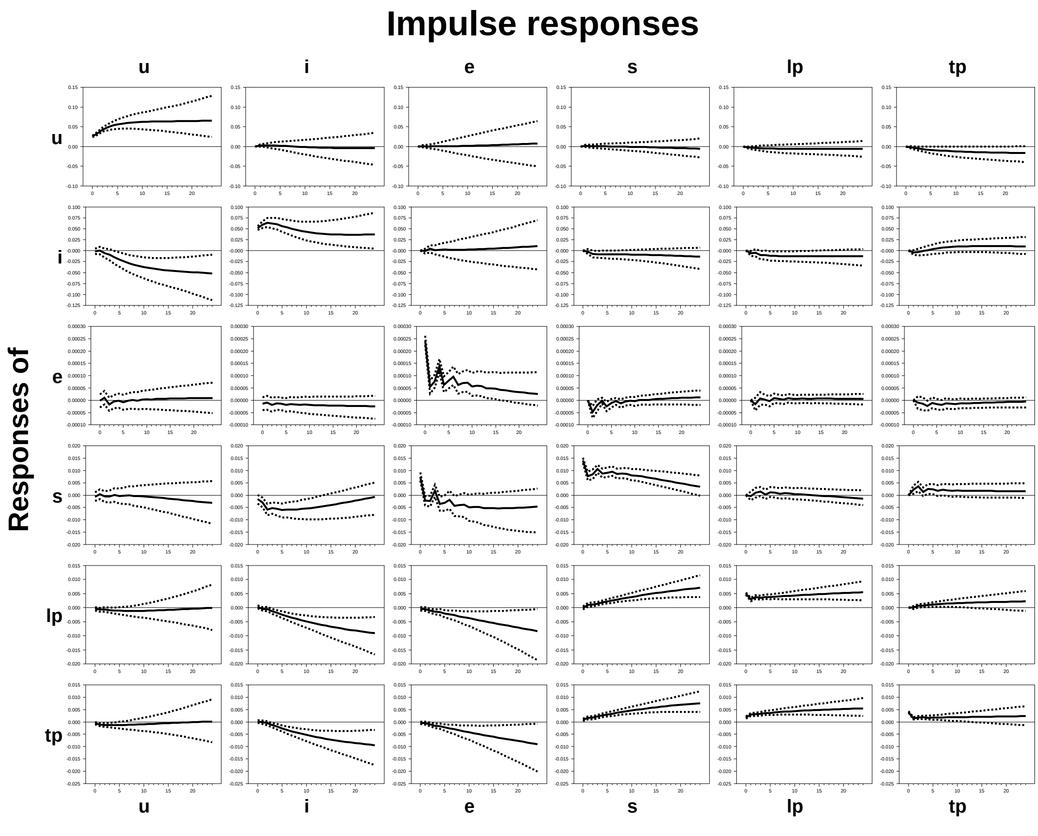

Figure 4.22: *Impulse responses. Ordering 5*

Chapter 5

Conclusion

This dissertation studied three important research questions related to liquidity of and price discovery in the housing market. Although we have limited ourselves here to the housing market, the findings might be relevant for other sectors of the real estate market or any other market that is characterized by illiquidity, indivisibility of goods and a high level of heterogeneity between goods.

Chapter 2 tests the empirical predictions from Taylor (1999) and Coles and Smith (1998). Taylor (1999) describes a model for the selling process of the housing market where potential buyers view the length of time a house has been for sale as a signal of inferior quality. The consequences are that the probability that a house will be sold declines with the time the house has already spent on the market. Furthermore, the probability that the seller will decide to withdraw the house from the market increases with time on the market. Coles and Smith (1998) describe a stock-flow matching model. The model predicts a sharp drop in the probability that a house will sell after the current stock of potential buyers has rejected to purchase the house and the house can only be matched to the flow of new potential buyers entering the market.

We have tested the empirical prediction from Taylor (1999) and Coles and Smith (1998) using duration analysis. This is the first study to take into account that the hazard rate of sale and the hazard rate of withdrawal are simultaneously determined. Therefore, we modelled the hazard rate of sale and the hazard rate of withdrawal simultaneously in a competing risks duration model with dependent unobserved heterogeneity. We find negative duration dependence in the hazard of sale and positive duration dependence in the hazard of withdrawal consistent with the theory in Taylor (1999). Consistent with Coles and Smith (1998), we also find the hazard of sale to be constant for a short period followed by a sharp drop.

Chapter 3 tests for asymmetric information in the housing market by recognizing that list prices should be obsolete in a housing market with symmetric information between sellers and buyers. We have tested for the effect of list price reductions on the time at which a house is on the market. Our model is a timing-of-events model as described in Abbring and Van den Berg (2003). We take into account that some houses are not sold but withdrawn from the market. Furthermore, we explicitly allow for selectivity in list-price reductions.

The 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.

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-effects matter 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 thus that it reduced the time on the market which again increases the expected transaction price.

The parameter estimates show positive duration dependence in the hazard rate of the repricing hazard. This study is actually 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 merely an association rather than a causal effect.

Chapter 4 investigates the price-volume correlation in the Dutch housing market. Several studies have found a positive price-volume correlation in the housing market (e.g. Miller and Sklarz (1986), Stein (1995), and Berkovec and Goodman (1996)). We document this correlation for the Dutch housing market and intend to identify the mechanism giving rise to this correlation using a Vector Error Correction Model. This is the first price-volume study to include information on list prices and the flow of houses entering the market. We also include information on transaction prices, the number of houses sold per month, mortgage rates, and unemployment in our Vector

Error Correction Model. According to the estimated model, shocks to market fundamentals (the mortgage rate) have an immediate and significant impact on the rate of sale, little impact on the rate of entry of new houses for sale, and a gradual impact on house prices. This pattern is consistent with a search model where buyers and sellers gradually learn about change in market conditions.

The three essays in this dissertation contribute to our understanding of the selling process in the housing market. However, there is still a lot to learn. The studies in this dissertation were conducted on seller information. Information on buyers is not available in our dataset. If buyer information ever becomes available, future studies could make a large contribution to the literature by studying the bidding behavior of potential buyers or the negotiation process between buyers and sellers.

Chapter 6

Samenvatting (Summary in Dutch)

Het kopen of verkopen van een woning is voor de meeste huishoudens de grootste financiële transactie die zij in hun leven zullen maken. Een woning is een illiquide en ondeelbaar stuk activa en de waarde van de woning beslaat een groot deel van de balans van huishoudens. Het verkoopproces wordt gekarakteriseerd door een hoge mate van onzekerheid, niet alleen over de uiteindelijke verkoopprijs, maar ook over de tijdsduur om het huis te verkopen, als het huis al verkocht wordt. Het verkoopproces wordt verder gecompliceerd door asymmetrische informatie tussen de verkoper en potentiële kopers over de werkelijke kwaliteit van de woning. Verkopers hebben een motief om te beweren dat hun woning van hoge kwaliteit is, maar potentiële kopers zullen op hun hoede zijn voor mogelijke verborgen gebreken aan de woning. Heterogeniteit tussen de set karakteristieken van te koop staande woningen zorgt ervoor dat potentiële kopers een aanzienlijke tijdsduur op de markt spenderen voordat zij een woning vinden die voldoende aansluit op hun preferenties.

Dit proefschrift bevat drie empirische onderzoeken over de woningmarkt. Al beperkt het proefschrift zich tot de woningmarkt, de resultaten kunnen relevant zijn voor andere sectoren binnen de onroerend goed markt of andere markten die gekarakteriseerd worden door illiquiditeit, ondeelbaarheid van goederen en een hoge mate van heterogeniteit tussen goederen.

Hoofstuk 2 test de empirische voorspellingen uit Taylor (1999) en Coles en Smith (1998). Taylor (1999) beschrijft een model voor het verkoopproces binnen de woningmarkt waarbij potentiële kopers de tijdsduur die een woning te koop staat interpreteren als een signaal van slechte kwaliteit van de woning. De consequentie is dat de kans dat een woning verkocht wordt afneemt met de tijdsduur die de woning al te koop heeft gestaan. Verder neemt de kans dat de woning door de verkoper van de markt wordt teruggetrokken toe naarmate de woning langer te koop staat. Coles en Smith (1998) beschrijven een stock-flow matching model. Het model voorspelt een scherpe daling in de kans dat een woning verkocht wordt nadat de huidige voorraad potentiële kopers de woning heeft afgewezen om te kopen en de woning alleen nog gematched kan worden met de stroom van nieuwe potentiële kopers die de markt betreden.

De empirische voorspellingen van Taylor (1999) en Coles en Smith (1998) worden in hoofdstuk 2 getest met behulp van duur-analyse. Dit is de eerste studie die er mee rekening houdt dat de hazard rate van verkoop en de hazard rate van terugtrekking van de markt gelijktijdig bepaald worden. Daarom modeleren wij de hazard rate van verkoop en de hazard rate van terugtrekking van de markt gelijktijdig in een competing risks duurmodel met afhankelijke niet-geobserveerde heterogeniteit. Wij vinden negatieve duurafhankelijkheid in de hazard rate van verkoop en positieve duurafhankelijkheid in de hazard rate van terugtrekking van de markt wat overeenkomt met de theorie in Taylor (1999). Consistent met de theorie in Coles en Smith (1998) vinden wij ook dat de hazard rate van verkoop constant is voor een korte periode gevolgd door een sterke afname.

Hoofdstuk 3 test voor asymmetrische informatie in de woningmarkt door in te zien dat vraagprijzen overbodig zijn in een woningmarkt met symmetrische informatie tussen kopers en verkopers. Wij hebben het effect van vraagprijs verlagingen op de tijdsduur dat een woning te koop staat getest. Ons model is een timing-of-events model, beschreving in Abbring en Van den Berg (2003). Wij houden in ons model ook rekening met het feit dat sommige woningen niet verkocht worden, maar worden teruggetrokken van de markt. Verder houden wij in het model rekening met selectiviteit in vraagprijs verlagingen.

De empirische resultaten laten zien dat de vraagprijs verlagingen de hazard van verkoop significant doen laten toenemen, maar ook de hazard rate van terugtrekking van de markt significant doen laten toenemen. De effecten zijn zeer substantieel. Een vraagprijs verlaging doet de hazard rate van verkoop met 83% toenemen en de hazard rate van terugtrekking van de markt met 44%. Vraagprijzen hebben geen formele juridische rol in de Nederlandse woningmarkt en daarom kunnen vraagprijzen alleen door de verkoper gebruikt worden om signalen aan de markt te verschaffen. In een markt met symmetrische informatie voegen signalen geen informatie toe. Daarom interpreteren wij het substantiële en significante effect van de vraagprijs verlagingen als bewijs van de aanwezigheid van asymmetrische informatie in de woningmarkt.

Wij hebben het belang van het corrigeren voor selectiviteit in vraagprijs verlagingen en het meenemen in de analyse van terugtrekkingen van de markt benadrukt. Onze resultaten bevestigen het argument van Caplin en Leahy (1996) dat zelf-selectie effecten er toe doen in markten met fricties, zoals de woningmarkt. Als laatste hebben wij het effect van vraagprijs verlagingen op de transactieprijs onderzocht. Vraagprijs verlagingen reduceren de verwachte transactieprijs, dit is het directe effect. Echter, ook de duur die de woning al te koop staat vóór de vraagprijs verlaging heeft een negatief effect op de transactieprijs. Het indirecte effect van een vraagprijs verlaging is daarom dat het de verwachte tijdsduur op de markt reduceert, wat weer de verwachte transactieprijs doet toenemen.

De parameter schattingen laten een positieve duurafhankelijkheid zien in de hazard rate van herprijzing. Dit is de eerste studie die empirisch bewijs vindt voor een positieve duurafhankelijkheid in de hazard rate van herprijzing, wat consistent is met de theorie in Lazear (1986). Onze bevinding dat een hogere initiële vraagprijs de kans op een vraagprijs verlaging doet toenemen is consistent met Lazear (1986), alhoewel onze schatting voor dit laatste slechts een associatie is in plaats van een causaal effect.

Hoofdstuk 4 bestudeert de prijs-volume correlatie in de Nederlandse woningmarkt. Verschillende studies vinden een positieve correlatie tussen het prijspeil in de woningmarkt en het aantal verkochte woningen (bijv. Miller en Sklarz (1986), Stein (1995), en Berkovec en Goodman (1996)). Wij documenteren deze correlatie voor de Nederlandse woningmarkt en hebben de intentie om het mechanisme te identificeren dat deze correlatie veroorzaakt met behulp van een Vector Error Correction Model. Dit is de eerste prijs-volume studie die informatie over vraagprijzen en de stroom te koop gezette woningen in de analyse meeneemt. Wij gebruiken ook informatie over transactieprijzen, het aantal verkochte woningen per maand, hypotheek rentes, en werkloosheid in ons Vector Error Correction Model. Volgens het geschatte model hebben schokken in de hypotheek rente een direct en significant effect op de verkoopsnelheid, weinig invloed op de snelheid waarmee woningen te koop worden gezet, en een geleidelijke impact op woningprijzen. Dit patroon is consistent met een search model waar koper en verkopers geleidelijk leren over schokken in marktcondities.

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