RESEARCH REPORT

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# RICS RESEARCH

## A REGIONAL HOUSE PRICE MODEL OF EXCESS DEMAND FOR HOUSING

Eric J. Levin and Gwilym Pryce
University of Glasgow, Scotland

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# About the authors

## Eric Levin

Eric Levin, PhD, was appointed as an Urban Studies Research Fellow in the Department of Urban Studies at the University of Glasgow in October 2005. Prior to that date he was a Reader in the Department of Economics at the University of Stirling. Born in Scotland in 1944, he studied and worked at the University of Glasgow following a business career. His research interests are financial economics, housing economics and labour economics.

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Gwilym Pryce, PhD, is Professor of Urban Economics and Social Statistics in the Department of Urban Studies, University of Glasgow. He currently leads the Housing Research Group and is Director of SHEFRN (Scottish Housing Economics and Finance Research Network). Gwilym also chairs the Social Science and Sustainable Behaviour Research Cluster (SBRC) of the University's Sustainability Network. He is a co-investigator and steering group member of the £1.4m AQMeN project, a major initiative funded by the ESRC to boost capacity in quantitative methods among social scientists in Scotland. Gwilym is the Principal Investigator on the socio-economic stream of the £1.6m Community Resilience to Extreme Weather consortium funded by the EPSRC estimating the housing and employment impacts of climate change. He is a member of the Expert Panel on Planning and Housing (Department of Communities and Local Government).

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# Foreword

**The Royal Institution of Chartered Surveyors has been carrying out a monthly survey of housing markets in Great Britain since 1978, seeking the views of chartered surveyors on their perceptions on likely trends in housing markets in their local area. Over time, this has become established as one of the leading and most highly regarded measures of activity in the housing market, being regularly and widely reported in the national press and taken note of by the Monetary Policy Committee of the Bank of England in their interest rate deliberations.**

Given the richness of the data that was being built up, we decided that the time was right to see if more could be done with this data, in order to see if it could help provide us with fresh insights into housing markets. So, we approached a number of leading housing researchers to see whether they could use this data to support innovative research that they felt could benefit from the data held in the housing market survey.

This report summarises the first such output, which has been produced by Eric Levin and Gwilym Pryce of the University of Glasgow, in which they combine data in the RICS housing market survey on stocks of unsold properties held by chartered surveyors with house price indices produced by the Nationwide, to see whether it is possible to create a new house price model which would incorporate how changing demand first impacts on observed prices and then feeds through to alter equilibrium prices for housing. This paper reports on their findings. Inevitably, although there is still some testing to be done on the fine detail of the model, they have developed a house price model which they feel would enable us to analyse:

1. the current deviation of actual price from the long-run equilibrium price, the difference being due to working off excess (insufficient) inventory of unsold houses that is altering the expected waiting time per bid.
2. the direction and amount by which the distribution of valuations is changing over time
3. the extent of the disequilibrium, that is, the deviation between long run equilibrium time on the market, implied time on the market, and actual time on the market.

RICS is committed to supporting researchers through the provision of the data contained in the housing market survey, in order to help bring about a greater understanding of the dynamics of the housing market. If you feel that there are research questions that you have that could be better explored by having access to this data, please contact me at the address below.

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# Summary and overview

## The problem

Why do falling house prices bring in their wake a large increase in the inventory of unsold homes with an accompanying decline in sales volume? Existing explanations for these phenomena include psychological reluctance to realize loss when the market values of houses fall below the prices that the current owners paid for them, and the negative equity effect on the owner of a property with a high loan-to-value ratio who requires the proceeds from the sale of the existing house to provide the down payment for the next home. Our analysis, while not precluding these factors, provides a simple, yet fundamental, statistical explanation that requires only the minimal assumption of a distribution of valuations for potential buyers and sellers that is not directly observable by house market participants.

Why should we be concerned that falling sales volumes and rising time on the market (TOM) are associated with falling prices? One implication is that it clouds the interpretation of headline price indices as an indicator of the state of the market. What we would really like to know, at any given point, is the equilibrium price of housing. This concept is rather illusive, however, and needs an appropriate theoretical framework to allow us to identify how to correctly define it. And once defined, it can, in principle be measured.

## The source of the problem

Valuation varies between individuals. This is not important as long as a mechanism exists for establishing the market clearing price at which the quantity supplied is equal to the quantity demanded. For example the market clearing price for oranges is determined in the vegetable auction market by the lowest buyer's valuation and the highest seller's valuation. The market clearing price of M&S shares is likewise determined by the lowest buyer's valuation and the highest seller's valuation, not by an auction but via market-makers who stand ready to act as counter-party principals for anyone wishing to buy or sell named stocks during trading hours in return for a bid-ask spread. Market-makers carry inventories of stocks. They interpret unexpected movements in their inventory for a given stock as "excess demand" i.e. a signal that the demand and/or supply curve has shifted and that the market is no longer clearing at the current price. They respond to unanticipated inventory movements by adjusting their buying and selling prices until the desired inventory levels are re-established at the new market-clearing equilibrium prices. However, the market-clearing mechanism for the housing market is very different. There is no institutional mechanism that directly reveals market-clearing prices in the house market because each house is unique with respect to location and characteristics. This is the origin of the exceptionally large swings in unsold inventories of unsold houses over the cycle. The central role of the distribution of intra-marginal valuations in explaining price, time on the market and the backlog of unsold inventory is explained in three stages.

***Resolution Stage 1 –*** There is unique optimal combination of expected price and time on the market that maximizes the gain to sellers net of selling costs. Variation in valuations over potential buyers means that the seller's decision to wait for an extra bid raises the expected sale price as more potential buyers become aware of the property for sale, but waiting for the extra bid also raises the cost of financing and depreciation (maintenance). Diminishing returns set in for waiting for an extra bid with respect to the sale price but not with respect to costs. The house seller maximizes gain net of selling costs by waiting up to that time on the market beyond which the expected incremental gain in the expected sale price from waiting for another bid is outweighed by the incremental cost of financing and maintenance. The first stage of the analysis concludes that there is a unique profit maximizing number of bids for a given coefficient of variation for the distribution of valuations and selling cost interest rate. If waiting time per bid is assumed to be constant, there is a unique expected time on the market and price combination that maximizes the seller's gain net of selling costs. However, this stage of the analysis is limited by the assumptions that the waiting time per bid is exogenously given and that the population of potential buyers and sellers are well-informed about the mean and standard deviation of the valuation distribution.

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*Resolution Stage 2 –* The seller's optimal price and time on the market combination itself varies with the state of the house market. The cost of waiting for an extra bid rises if the average waiting time per bid lengthens. Bids arrive slowly during the slump when there is a large overhang of the unsold stock of houses on the market relative to the rate that houses are being sold. The cost of waiting for an extra bid rises with the stock of unsold houses for sale relative to the number of houses being sold per period at each time t. That is, the seller's optimal price and time on the market combination alters with the state of the house market. When there is an observable large overhang of unsold houses for sale at time t relative to the rate at which houses are actually being sold per period, the cost of waiting for an extra bid rises. This lowers the optimal price and number of bids at which the seller maximizes gain net of selling costs.

*Resolution Stage 3 –* Observable change in the overhang of unsold houses relative to the rate at which houses are actually selling provides a signal that the unobservable zero excess demand market clearing price has altered. The ratio of unsold houses to the rate at which houses are being sold, the implied time on the market, provides an observable signal that the distribution of valuations has shifted. The shift in the inferred distribution of valuations in turn causes a shift in the expected increase in the selling price for waiting for another bid. Therefore the third stage of the analysis recognizes that the state of the house market measured by the observable implied time on the market (unsold stock divided by rate at which houses are selling) alters both the cost of waiting for another bid and the expected change in the selling price for waiting for another bid.

These relationships are incorporated into a dynamic algebraic model and an empirical analysis that estimates:

1. how deviation from the long run overhang of unsold houses relative to sales rate alters the profit maximizing price and time on the market combination
2. how deviation from the long run overhang of unsold houses relative to sales causes a subsequent revision in the unobservable market clearing price.

In short, the house market is never in equilibrium at the unobservable market clearing prices. Observed prices diverge from the market-clearing prices for two reasons. First, deviation of the observed overhang of unsold houses relative to sales rates from the long run level (the implied time on the market,T2) arising from past pricing errors causes sellers to take advantage of this situation by altering their profit maximizing price and time on the market away from the long run market clearing equilibrium. Second, deviation of T2 from its long run equilibrium value causes a revision in the perceived distribution of valuations and this alters the change in gross seller price for waiting for an extra bid.

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## The empirical model

An empirical analysis applied the algebraic econometric model using RICS regional monthly data on unsold houses and rate of sales in the last three months to calculate the implied time on the market T2. Quarterly regional price data was taken from the Nationwide. The empirical results show the expected signs, are statistically significant at the 5% level and support the theoretical analysis. Estimates of the unobservable long run time on the market, the short run equilibrium profit maximizing deviation from the long run price and time on the market, and the change in the distribution of valuation for a deviation in the implied time on the market from the long run equilibrium are backed out from the empirical results. The theory cannot provide any basis for deciding the real time it takes for the perception of the distribution of valuations to alter in response to deviations in T2. This is an empirical matter. The analysis is run on quarterly data but it takes two quarters for deviations in T2 from the long run value to impact on the inferred distribution of valuation. The RICS data is monthly but we were unable to obtain time series monthly regional house price data. If monthly regional house price data could be made available, it would be possible to investigate the precise lag structure of the change in the distribution of valuations.

## The insights

The insights are that if all new information was instantly impounded in house prices, then the average actual time on the market (T1) would not alter over time, the implied time on the market (T2) i.e. the ratio of unsold houses to sales rate would also be constant over time and both of these would equal T3, the long run equilibrium time on the market. All adjustments would occur via changing house prices. But the real world is very different.
The analysis shows that there is no efficient system for prices to rapidly eliminate excess demand, and it is the build-up or run-down of unsold houses on the market that leads to a) actual prices diverging from equilibrium prices in order to eliminate unsold inventory left over from past pricing errors, and b) a re-assessment as to what the equilibrium price actually is. These are two ongoing processes that never end.

# 01 Introduction

## 1.1 Background to the study

This project arose out of a desire to make better use of the RICS housing market data which held out the potential to deepen our understanding of the dynamics of excess demand and price expectations in the UK housing market. Our original insight was that it may be possible to use the data to estimate optimal time-on-the-market from the variables collated in the RICS survey. This in turn opened up the possibility of combining the RICS variables with published house price indices (such as the Nationwide or Halifax index) in order to calculate a liquidity-adjusted house price index.

This line of reasoning had the potential to transform our knowledge of current market dynamics. Existing house price series take no account of changes in selling times. So, although housing demand may have plummeted in an area, prices may appear relatively stable. Our original idea was to adapt existing stock-adjustment models of price adjustment in a disequilibrium market. In such a model, stocks of unsold properties build up, demand collapses, but prices remain sticky. As a consequence, house price indices can give a highly misleading indication of the state of the market, and distort comparisons of different markets. The original proposition was to create an adjusted price index that would show the market clearing price index after removing both price mistakes (deviations from the zero-excess demand price) and also removing price adjustments that sellers make to take advantage of deviations of actual TOM (time on the market) from optimal TOM when there are “to few” or “too many” houses for sales relative to actual sales.

Having embarked on this avenue of research, we encountered a theoretical problem: *how do market participants know when stocks build up?* Unlike firms, sellers do not have many houses to sell, and so do not have an inventory of stock accumulation to signal shifts in market demand relative to supply. They only have one house to sell, so how do they know whether prices are being adjusted upwards or downwards? The answer is time on the market. TOM acts as a critical signal to buyers and sellers – a proxy indicator of stock accumulation (unsold properties).

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In principle, this realisation adds to the simplicity and elegance of our theory – everything becomes endogenous – determined from within the model – rather than relying on externally determined drivers. Unfortunately, the fact that TOM itself is part of the adjustment process greatly increased the difficulty of devising an internally consistent theoretical model. We have invested significant time over the past year, therefore, devising such a model and believe our efforts have reaped a theoretical framework that is significantly more innovative than the one originally envisaged.

## 1.2 Intuitive introduction to the model

UK house markets operate within an institutional framework whereby the seller typically posts a list price and then waits for potential buyers to bid for the house. "Time on the market" is the time that elapses between the date that a house is placed on the market and the date when it is sold. This study seeks to explain the wide swings in time on the market observed across house market booms and slumps using a set of dynamic disequilibrium relationships between the house sellers' profit maximising time on the market, time on the market implied by the stock of unsold houses for sale relative to the rate at which houses are being sold, and the long run equilibrium zero excess demand time on the market.

The analysis models the dynamic interactions between these variables in order to identify deviations from the unobservable equilibrium price and time on the market within a general framework suitable for any non-liquid market. In liquid markets market prices are determined by marginal buyers and sellers. However, in non-liquid markets the distribution of valuations within the population of potential buyers and sellers takes centre stage, and intra-marginal valuations determine both price and time on the market.

This may be illustrated by considering the short run equilibrium price and time on the market for a hypothetical database of 50,000 house valuations for a particular type of house k, with a mean of £100,000 and standard deviation of £10,000 that represents the population of potential bids. As the number of bids per house sale rises, the average value of the mean bid stays fairly constant at around £100,000, but the average value of the maximum bid rises steadily with the number of bids to over £115,000 at ten bids. Figure 1 illustrates this relationship, showing the average value of the maximum bid as a function of the number of bids for this valuation distribution.

*Figure 1 Number of Bids and the Maximum Bid Price*

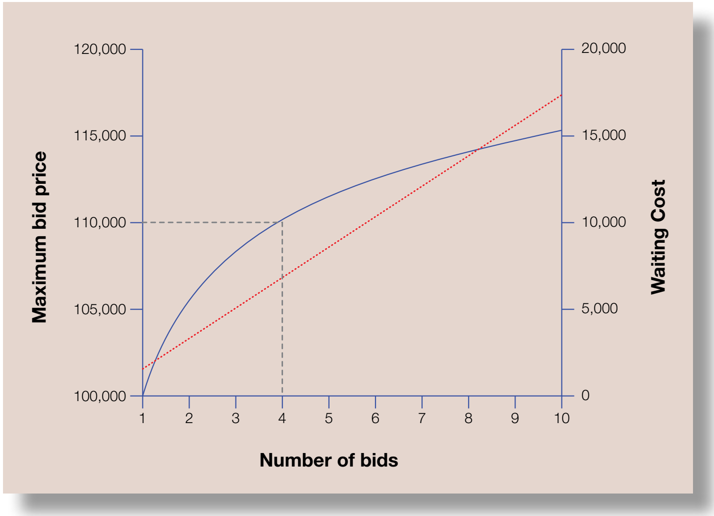


Figure 1 also shows that the waiting cost of selling the house rises with the number of bids. Waiting for an extra bid requires longer time on the market which raises the expected sale price as more potential buyers become aware of the property for sale but also raises the cost of financing and depreciation (maintenance). The house seller's profit is maximised at that time on the market beyond which the expected incremental gain in the expected sale price from waiting for another bid would be outweighed by the incremental cost of financing and maintenance. In the example of Figure 1 with a mean valuation of £100,000, a standard deviation of £10,000 and a waiting cost of 1.5% of the expected sale price per month, the seller's gain is maximised by setting a reservation price of £110,227 with the expectation of four bids. Diminishing returns set in for waiting for an extra bid with respect to the sale price but not with respect to costs, and this ensures a unique optimal price/time on the market $P^*T^*$ that maximises profit to the seller.

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A second definition of time on the market $(T2)$ is implied by the stock of unsold houses for sale relative to the number of houses being sold per period. $T2$ is calculated as the number of unsold houses for sale at time t divided by the rate at which houses are actually being sold per period at time $t$. $T2$ is determined by the overhang of the unsold stock of houses on the market relative to the rate that houses are being sold. The cumulative effect of past pricing errors on the current stock of unsold houses causes either a shortage or a glut of unsold properties "currently" on the market at any time $t$.

A third definition of time on the market is the unobservable long run equilibrium time on the market $(T3)$ and its corresponding zero excess demand price $(P3)$. The house market is typically observed during periods of positive or negative excess demand with dynamic relationships between $P^*T^*$ $P2T2$ and $P3T3$. These dynamic feedback processes adjust the implied time on the market $T2$ and the profit maximising time on the market $T^*$ over subsequent periods. Absent external shocks, this process would lead to a long run zero excess demand equilibrium time on the market $T3$ that is equal to the profit maximising time on the market with $T1=T2=T3$. However, long run equilibrium is never attained because the zero-excess demand price itself changes over time.

The analysis examines the processes by which the time on the market that a house is on sale both determines and is determined by its selling price. A model is developed in which observable transaction prices maximise expected gain to sellers but do not correspond to market-clearing zero excess demand prices. The model incorporates dynamic causal feedbacks between $T^*$ the profit maximising time on the market, $T2$ the implied time on the market and $T3$ the long run zero excess demand market-clearing time on the market and their corresponding prices.

This dynamic system explains why time on the market shortens as house prices rise during boom periods of the house price cycle, and lengthens as house prices fall during house market slumps. The house market model is also general in the sense that it could be applicable to any illiquid durables market that involves waiting, for example the market for second-hand cars but would not apply to a liquid market such as a stock market in which there are market-makers standing ready to provide immediacy by acting as counterparties for buyers and sellers in return for a bid-ask spread.

# 02 Theoretical model

Levin and Pryce (2007) have noted that the phenomenon of extreme bids observed during house price booms is an inevitable statistical outcome of multiple bids that occur during periods of high demand. A normal distribution of valuations for a representative house implies that the expected sale price is the mean of the maximum bid, which rises at a decreasing rate with the number of bids. As the number of bids per auction rises, the average value of the mean bid stays fairly constant, but the average value of the maximum bid rises with the number of bids. That is,

$$P = f(B,\mu,\sigma) \quad \frac{\partial P}{\partial B} > 0, \ \frac{\partial^2 P}{\partial B} < 0 \tag{1}$$

where $P$ is the price at which the house is sold, $B$ is the number of bids, $\mu$ is the mean and $\sigma$ is the standard deviations of the valuation distribution.

The number of bids for a house is by definition the time that the house is on the market divided by the average waiting time per bid.

$$B = \frac{T}{tpb} \tag{2}$$

where $T$ is the time on the market and $tpb$ is the average waiting time per bid. Substituting (2) into (1) gives

$$P = f(\frac{T}{tpb},\mu,\sigma) \quad \frac{\partial P}{\partial T} > 0, \ \frac{\partial^2 P}{\partial T} < 0 \tag{3}$$

The cost of keeping a house on the market $C_t$ includes maintenance (or depreciation) and a financing cost for the time that the house is on the market. This can be expressed as

$$C_t = f(T_t) \quad \frac{\partial C}{\partial T} > 0 \tag{4}$$

## 2.1 Short Run Equilibrium

The seller's profit $\pi$ is the sale price minus the costs of $T$. That is,

$$\pi_t = P_t - C_t \tag{5}$$

The seller's profit at time t is maximised by substituting (3) and (4) into (5), giving

$$\pi = f(\frac{T}{tpb_t}, \ \mu_t, \ \sigma_t) - f(T) \tag{6}$$

which is the algebraic expression of Figure 1. The profit maximising equilibrium price $P^*t$ and time on the market $T^*t$ at time t is given by differentiating $\pi$ with respect to $T$, setting this expression equal to zero, solving for $T^*$, and substituting this value into (3) to solve for $P^*$. The equilibrium values $P^*t$ and $T^*t$ will vary over time because they depend on the particular value for $tpb$ ruling at time $t$. The waiting time per bid in turn depends on whether the house market is in a boom or a slump at time $t$. That is, $tpbt$ depends on the state of the house market at time $t$.

## 2.2 Long Run Equilibrium

The house market is in long run equilibrium at the zero excess demand price $(P3)$ and time on the market $(T3)$ but this long run equilibrium $P3$ $T3$ is unobservable. House markets are seldom in long run equilibrium, prices and time on the market invariably being in a disequilibrium state of positive or negative excess demand. There are two dynamic processes that generate continuous adjustments between long run equilibrium and observed price and time on the market.

The first process is caused by a legacy deficit or surplus of unsold houses for sale caused by past pricing errors. At any given time there is a shortage (glut) of unsold houses for sale on the market relative to the rate at which they are being sold, caused by historical prices having been set too low (high). A shortage of unsold houses causes time per bid to fall, which causes the observable profit maximising price $P^*$ to rise. This same unsold inventory correction process would likewise help eliminate any legacy overhang of excess unsold houses effect of past pricing errors.

# Theoretical model

The second process concerns the mean of the valuation distribution $\mu$ in *(1)* changing over time. That is, the zero excess demand market clearing price itself changes over time as circumstances change. In some cases the new circumstances that raise the zero excess demand market clearing price are public knowledge; both buyers and sellers revise their house price valuations without any impact on the stock of unsold houses for sale. In other cases when the new circumstances are not known to everybody, informed trading impacts on the unsold stock of houses for sale. Once again this alters time per bid, the profit maximising price $P^*$, and this causes an ex post revision of house price valuations towards the new long run equilibrium *T3P3*.

These relationships may be described more formally. The waiting time per bid *tpbt* depends on whether the house market is in a boom or a slump at time $t$. The state of the house market can be expressed as the ratio of unsold house to house sales $\frac{H_t}{S_t}$ where $H_t$ is the number of unsold houses on the market for sale at time $t$, and *St* is the sales rate at time t expressed as the number of house sold during the most recent period. The state of the house market at time t, $T2_t$, can be defined as:

$$T2_t = \frac{H_t}{S_t} \tag{7}$$

where $H_t$ is the number of unsold houses for sale on the market at time $t$, and $S_t$ is the sales rate at time $t$ expressed as the number of house sold in the period ending at time $t$. It is important to note that this definition of the state of the house market expresses an implicit time on the market.

The distinction between $T^*$ and $T2$ is that $T^*$ is a decision variable whereas $T2$ is a state variable. $T^*$ can be altered by a decision to sell at a higher or lower price. $T2$ expresses the existing state of the house market as the relationship between the number of houses for sale and the rate at which houses have been selling.

There is a dynamic relationship between $T^*$, $T2$ and $T3$. Time per bid $tbp_t$ depends on the number of houses on the market for sale relative to the rate at which houses are selling. That is,

$$tbp_t = f(T2_t) \quad \frac{\partial tbp}{\partial T2} > 0 \tag{8}$$

Substituting *(8)* into *(6)*, the profit maximising seller price $P^*$ rises when time per bid is low.

$$P^* = f(tpb) \quad \frac{\partial P^*}{\partial tpb} < 0 \tag{9}$$

The profit maximising price $P^*$ is high when $T2$ is low. Substitute *(8)* into *(9)* gives:

$$P^* = f(T2) \quad \frac{\partial P^*}{\partial T2} < 0 \tag{10}$$

$T2<T3$ implies a shortage of houses on the market for sale relative to the rate at which houses are currently being sold. This shortage may either be caused by past prices being too low, or because of informed trading when the zero excess demand price rose without public knowledge. In either case the low inventory of unsold houses reduces $T2$, which lowers the time per bid tpb, which in turn raises the seller's profit maximising selling price P*. The perception of low $T2$ feeds back to raise the distribution of valuations, and this raises $T2$ by increasing the number of new houses coming on the market and reducing the number of houses being sold. In the absence of any further disturbance this dynamic process continues until there is convergence with $T^*=T2=T3$ with $P^*=P2=P3$ and the house market in long run equilibrium.

# 03 Empirical Model

An empirical model is developed to explore these dynamic relationships between time on the market and house prices. This model is based on the assumption that observable implied time on the market (stock of houses for sale to monthly sales ratio) provides a signal to house market participants of excess demand caused by informed trading that the demand and/or supply curve has shifted and that the market is not clearing at the current price. House market participants adjust their perception of the zero excess demand price in response to unanticipated observed excess demand.

The observed selling price for a representative house at the beginning of period $t$, $P^*_t$, consists of two components. The first component, $P3_t$, is the perceived zero excess demand selling price in that area. The second component, $\theta t$, is an adjustment caused by sellers adjusting their profit maximising $P^*T^*$ to take advantage of deviations in observed $T2$ from the optimal $T3$ caused by past pricing errors. That is:

$$P_t^* = P3_t + \theta(T2_t - T3) \qquad (11)$$

The price adjustment is modelled in terms of the seller's response to the deviation of the unsold houses overhang ratio $T2$ at time $t$ from the long run equilibrium $T3$. This adjustment occurs during booms or slumps that make it profitable for sellers to adjust the profit-maximising time waiting for bids by raising or lowering their reservation price above or below the zero excess demand price. This is revealed by the deviation between the actual $T2$ and long run $T3$ at time $t$, and the slope of the function $\frac{\Delta P^*}{\Delta T2}$ that determines the change in the seller's profit maximising price for a change in the unsold houses overhang ratio $T2$. $T3$ is the long run optimal time on the market; $T2t$ is implied time on the market at the beginning of period $t$; $\theta$ is $\frac{\Delta P^*}{\Delta T2}$ as sellers raise price to take advantage of a shortage of houses on the market caused by past pricing errors.

The valuation distribution $\mu$ in *(1)* also changes over time. Changes in the zero excess demand price $P3$ over time consists of two components. The first component is publicly available new information that alters expectations about future house prices. The second component is the perception of new private information. Private information is defined as information that is known to informed market participants but is not generally available to sellers and estate agents. Estate agents cannot directly observe the private information component, but they are able to observe its effect on unanticipated movements in $T2_t$. More formally:

$$P3_t = P3_{t-1} + \eta(T2_t - T3) + \varepsilon_t \qquad (12)$$

where: $\eta(T2_t - T3)$ is the change in the zero excess demand price between the beginning of period $t$-$1$ and the beginning of period $t$ attributable to private information; and $\varepsilon_t$ is the shift in the zero excess demand market price attributable to public news incorporated into the price since the last period.

# Empirical Model

Private information causes an unexpected shift in the demand for houses that is initially observed as an unexpected change in $T2_t$ the current price. Sellers, guided by estate agents, attribute the deviation in $T2$ from $T3$ as unanticipated excess demand caused by the activities of informed buyers and sellers. Buyers, sellers and estate agents respond to observable deviation of $T2_t$ from $T3$ by adjusting their perception of the zero excess demand price at time $t$ by an amount equal to the product of the observed unanticipated excess demand and the slope of the excess demand curve required to eliminate it. Therefore, the change in price necessary to eliminate the deviation between $T2$ and $T3$ defines the slope of the excess demand curve $\eta = dP/dT2$ facing sellers.

Substituting *(12)* into *(11)* gives:

$$P_t^* = P3_{t-1} + \eta(T2_t - T3) + \theta(T2_t - T3) + \varepsilon_t \qquad (13)$$

The unobservable zero excess demand price, $P3_t$, can be eliminated by subtracting *(11)* lagged one period from (13) which gives the first difference of the observed price, $P^*_t$:

$$P_t^* - P_{t-1}^* = P3_{t-1} + \eta(T2_t - T3) + \theta(T2_t - T3) + \varepsilon_t - P3_{t-1} - \theta(T2_{t-1} - T3) \qquad (14)$$

which eliminates $P3$ from the equation.

Equation *(14)* can be written as a regression equation of the form:

$$P_t^* - P_{t-1}^* = a + bT2_t + cT2_{t-1} + \mu \qquad (15)$$

where :

$$a = -\eta T3$$
$$b = \eta + \theta$$
$$c = -\theta \qquad (16)$$

and $\mu$ is a well-behaved error term. The estimates of the parameters $a$, $b$ and $c$ can be used to derive estimates of $\eta$ $\theta$ and $T3$ by solving these three equations for the unknowns. The parameter estimate of "$c$" = $-\theta$ = $\frac{-\partial P1}{\partial T2}$ summarises the change in price for a deviation in $T2$ from the long run equilibrium T3 that maximises the seller's profit.

# Empirical Model

## 3.1 Data

### *Quarterly Change in House Prices* $P1_t - P1_{t-1}$

Quarterly non-seasonal-adjusted, house price indexes for the nine regions and Wales were obtained at http://www.nationwide.co.uk/hpi/downloads/All_prop.xls

The quarterly change in price is calculated as $(P_t - P_{t-1})/P_{t-1}$

### *Time on the Market* $T2$

The Royal Institution of Chartered Surveyors (RICS) provided non-seasonally adjusted monthly data April 1994 to June 2008 for the nine regions and Wales with average sales per chartered surveyor over the last three months and average unsold house stock per chartered surveyor at the end of each month. $T2$ for each quarter was calculated as the average unsold house stock for the first month of each quarter divided by the average sales "over the last three months".

## 3.2 Results

The regression estimation equation differs from *(15)* in a number of respects. First, the dependent variable was expressed as a proportional change rather than an absolute change in order to eliminate bias caused by effects of inflation over the sample period. Second, a logarithmic relationship was used to take account of the curvature of $dP/dT2$ as a function of $T2$ associated with the curvature of the number of bids as a function of time as shown in Figure 1. Third, the variable mortgage interest rate was included as an independent variable in order to control for the effect of interest rate changes on the finance cost of waiting for another bid. Fourth, quarterly seasonal dummies were included to control for seasonal effects. The parameters of interest in *(15)* were estimated by fitting the following one-way fixed-effects model for the quarterly data set 1994:2 to 2008:2

$$\frac{P1_{it} - P1_{it-1}}{P1_{it-1}} = a + b \cdot LnT2_{it} + c \cdot LnT2_{it-1} + d \cdot mortgage\,rate_t + e \cdot q2 + f \cdot q3 + g \cdot q4 + \alpha_i + \varepsilon_{it}$$

where $\frac{P1_{it} - P1_{it-1}}{P1_{it-1}}$ is the growth in the price of houses in region $i$ in year $t$, a is a constant, mortgagee rate is the variable mortgage interest rate, $\alpha i$ is a time-invariant, region-specific fixed effect, and $\varepsilon_{it}$ is a random error term. The estimates of *(17)* are shown in Table 1.

# Empirical Model

### Table 1

### House Price Growth - Model Estimates

| Model | House price growth (quarterly) | |
|---|---|---|
| | Parameter | T-Statistic |
| Constant | 0.084849 | 10.94 |
| $LnT2_t$ | -0.044321 | 11.44 |
| $LnT2_t$-2 | 0.010914 | 3.00 |
| Mortgage rate | -0.005753 | 4.71 |
| Q1 dummy | 0.010790 | 3.81 |
| Q2 dummy | 0.030600 | 10.43 |
| Q3 dummy | 0.013156 | 4.67 |
| | $R^2$=.43<br>DW = 2.01<br>N=550 | |
| Region Effects | | |
| Greater London | 0.006228 | |
| South East | -0.007102 | |
| East Anglia | -0.009924 | |
| South West | -0.000312 | |
| Yorks. & Humberside | -0.003543 | |
| North | 0.002730 | |
| North West | 0.005240 | |
| West Midlands | -0.004434 | |
| East Midlands | -0.001129 | |
| Wales | 0.012247 | |

Substituting the estimated parameter values into (16) gives

$$\theta = -c = -0.010914$$

$\theta$ measures the price response to the unsold houses overhang that occur during booms or slumps that make it profitable for sellers (without altering their perception of $\mu$ and $\sigma$) to adjust the profit-maximising time waiting for bids by raising or lowering their reservation price above or below the zero excess demand price. The profit maximising price $P^*$ is raised about one percent when the natural logarithm of $T2$ has shortened by unity.

Turning to the excess demand price adjustment, $\eta$ defines the excess demand curve $dP3/dLnT2$ facing sellers.

$$b = \eta + \theta = -0.044321$$

$$\therefore \eta = -0.044321 + 0.010914 = -0.03341$$

A 3.3 percent price rise is required to eliminate excess demand when the natural logarithm of $T2$ shortens by unity below long run equilibrium natural logarithm of T3. For example when $logT2$ exceeds $logT3$ by unity, this signals a reduction in long run equilibrium $P3$ of 3.3 percent, that is, the valuation distribution $N(\mu,\sigma)$ has shifted 3.3 percent to the left.

Turning to the long run equilibrium level $T3$, the constant term in Table 1 can be substituted into *(16)* to give

$$a = -\eta \cdot T3 = 0.084849$$

$$\therefore T3 = \frac{0.084849}{0.03341} = 2.5$$

That is, the estimated unobservable long run equilibrium implied time on the market $T2$ is 2.5 quarters.

The analysis attempted to decompose quarterly house price changes into components that co-exist in dynamic equilibrium. There are two advantages to this approach. First, it should be possible to back out the unobservable equilibrium prices and time on the market. The estimates for $T3$ and $\theta$ can be substituted into *(11)* for each region for each period to calculate the estimated deviation between the current actual price and the current equilibrium price $P3_t$. Second, the parameter estimates of equation *(17)* shown in Table 1 can be used to calculate a forecast for the next quarter, taking account of regional effects and assuming no change in $T2$-$T3$. These estimates are shown in Table 2 using the Nationwide quarterly regional house price data and the regression estimates shown in Table 1. The third quarter prospect for house price changes is given in column 2 of Table 1, and the long run equilibrium prices for the second quarter of 2008 are shown in column 2 of Table 1.

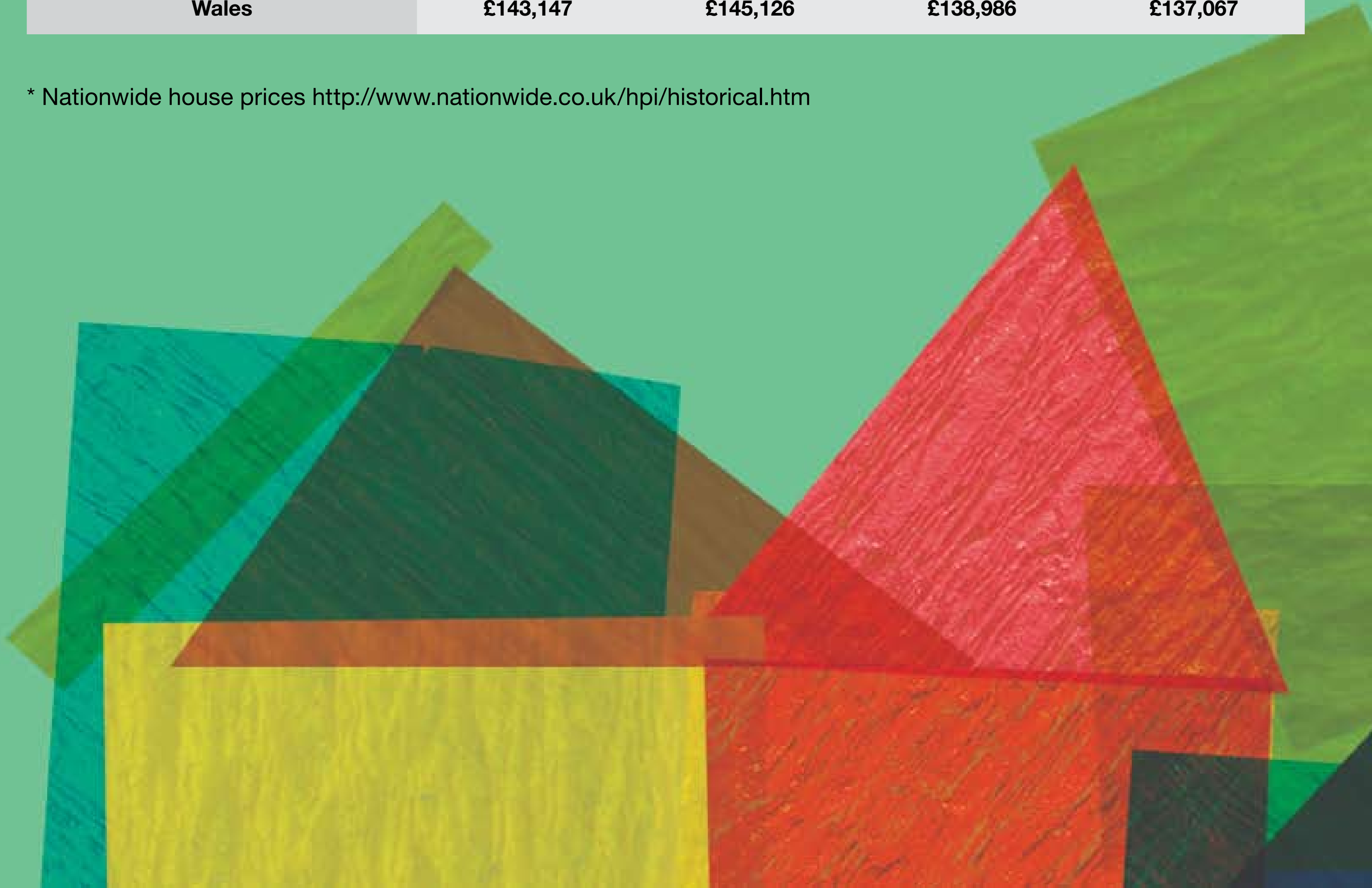
# Empirical Model

**Table 2**

**House Price Disequilibrium - Model Estimates**

| Region | P* Actual price 2008:2 | P3 Long run equilibrium 2008:2 | P3 Long run equilibrium (forecast) 2008:3 | P* (forecast) 2008:3 |
|---|---|---|---|---|
| Greater London | £285,568 | £287,102 | £282,380 | £280,865 |
| South East | £204,292 | £205,438 | £201,910 | £200,779 |
| East Anglia | £172,164 | £173,703 | £168,950 | £167,442 |
| South West | £194,714 | £196,331 | £191,341 | £189,754 |
| Yorks. & Humberside | £146,074 | £147,185 | £143,757 | £142,665 |
| North | £129,700 | £131,043 | £126,887 | £125,574 |
| North West | £150,162 | £151,984 | £146,338 | £144,564 |
| West Midlands | £156,219 | £157,861 | £152,781 | £151,177 |
| East Midlands | £147,413 | £148,460 | £145,234 | £144,205 |
| Wales | £143,147 | £145,126 | £138,986 | £137,067 |

* Nationwide house prices http://www.nationwide.co.uk/hpi/historical.htm



# Empirical Model

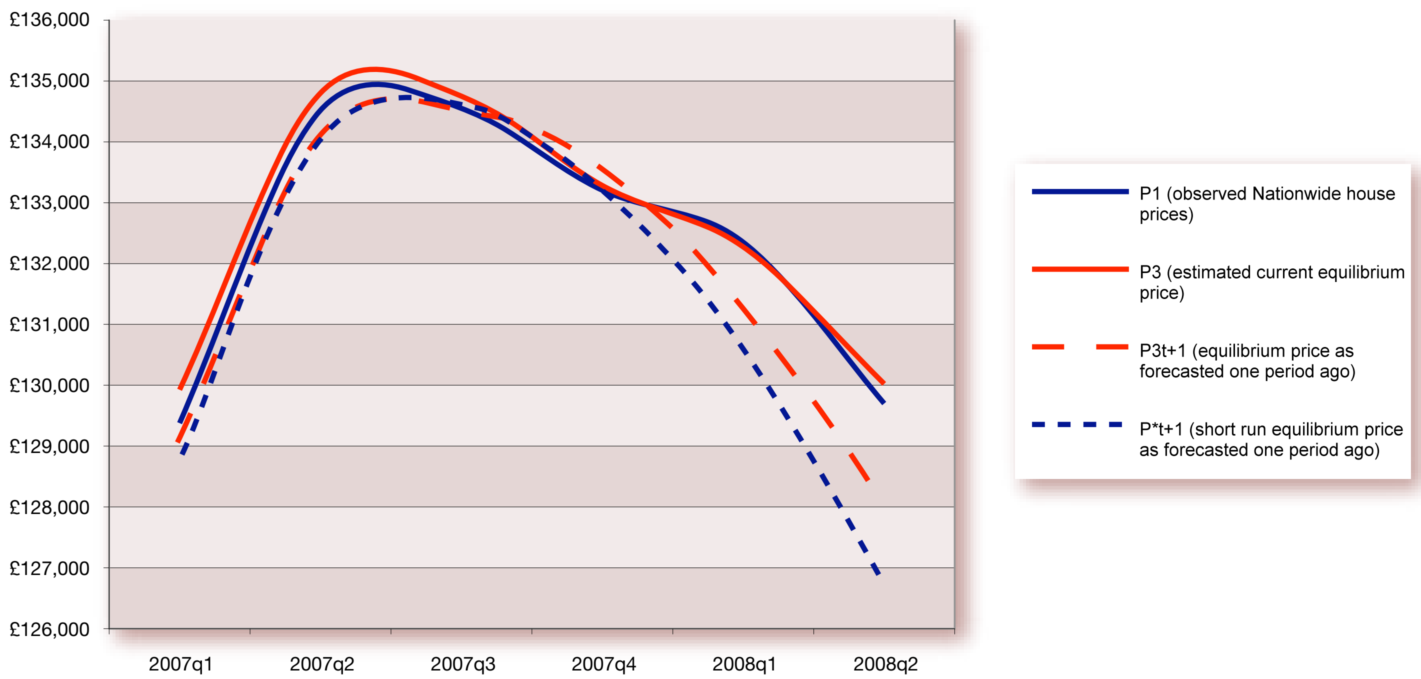
## 3.3 Results for "The North" for 1994q4 to 2008q2

Given the complexity of the model, it is no mean feat to calculate the values of P3, $P3_{t+1}$ (i.e. forecast equilibrium prices, P3), and $P1_{t+1}$ (i.e. forecast actual prices, P1) for all periods and for all regions. So we present in table 3 and figure 2 selected results for a single region to illustrate the kind of outputs the model might produce.

We are surprised at how close the equilibrium price (P3) and the actual price (P1) appears to be in most periods. This is likely to be due to the fact that we were unable to obtain regional monthly house price data so the models have been estimated quarterly. We would anticipate that quarterly house price data would uncover more marked differences between observed and equilibrium prices and be able to unpick a more compelling story about the short run adjustment of the housing market.

## Comparing equilibrium and actual prices since 2007q2

(Model based on Nationwide quarterly house prices and RICS market dynamics data)



# Empirical Model

### Table 3 P1, P3, $P3_{t+1}$ and $P_{t+1}^*$ Estimates for The North

| | P1 (observed Nationwide house prices) | P3 (estimated current equilibrium price) | $P3_{t+1}$ (equilibrium price as forecasted one period ago) | $P^*_{t+1}$ (short run equilibrium price as forecasted one period ago) |
|---|---|---|---|---|
| 1994q1 | £41,884 | £42,227 | £40,994 | £40,517 |
| 1995q1 | £45,858 | £46,295 | £44,648 | £43,951 |
| 1995q2 | £44,871 | £45,392 | £43,223 | £42,692 |
| 1995q3 | £42,305 | £42,966 | £41,351 | £40,875 |
| 1995q4 | £43,119 | £43,648 | £42,110 | £41,662 |
| 1996q1 | £43,402 | £43,901 | £42,468 | £41,949 |
| 1996q2 | £45,144 | £45,625 | £43,917 | £43,512 |
| 1996q3 | £43,838 | £44,375 | £43,122 | £42,727 |
| 1996q4 | £45,552 | £45,972 | £44,684 | £44,283 |
| 1997q1 | £44,953 | £45,364 | £44,118 | £43,698 |
| 1997q2 | £45,634 | £46,044 | £44,700 | £44,383 |
| 1997q3 | £47,048 | £47,496 | £46,466 | £46,357 |
| 1997q4 | £47,519 | £47,856 | £47,514 | £47,262 |
| 1998q1 | £47,274 | £47,384 | £46,614 | £46,305 |
| 1998q2 | £49,336 | £49,598 | £48,590 | £48,229 |
| 1998q3 | £49,211 | £49,537 | £48,409 | £48,160 |
| 1998q4 | £48,532 | £48,893 | £48,121 | £47,844 |
| 1999q1 | £48,349 | £48,599 | £47,743 | £47,209 |
| 1999q2 | £50,184 | £50,473 | £48,746 | £48,604 |
| 1999q3 | £51,026 | £51,596 | £51,137 | £51,004 |
| 1999q4 | £51,127 | £51,275 | £50,866 | £50,768 |
| 2000q1 | £50,606 | £50,738 | £50,438 | £50,329 |
| 2000q2 | £53,493 | £53,597 | £53,240 | £53,075 |
| 2000q3 | £52,757 | £52,872 | £52,369 | £52,392 |
| 2000q4 | £53,492 | £53,659 | £53,731 | £53,804 |
| 2001q1 | £54,720 | £54,696 | £54,924 | £54,876 |
| 2001q2 | £53,951 | £53,878 | £53,735 | £53,558 |
| 2001q3 | £59,752 | £59,804 | £59,203 | £59,318 |
| 2001q4 | £59,510 | £59,706 | £60,059 | £60,192 |
| 2002q1 | £59,504 | £59,389 | £59,791 | £60,056 |
| 2002q2 | £65,842 | £65,696 | £66,588 | £66,726 |
| 2002q3 | £70,928 | £70,614 | £71,065 | £71,351 |
| 2002q4 | £75,657 | £75,499 | £76,430 | £76,836 |
| 2003q1 | £81,226 | £80,899 | £82,216 | £82,648 |
| 2003q2 | £87,082 | £86,619 | £88,012 | £88,072 |
| 2003q3 | £93,334 | £92,843 | £93,037 | £93,507 |
| 2003q4 | £98,448 | £98,381 | £99,904 | £100,344 |
| 2004q1 | £108,255 | £107,708 | £109,161 | £109,463 |
| 2004q2 | £115,790 | £115,280 | £116,259 | £116,699 |
| 2004q3 | £121,378 | £121,042 | £122,444 | £122,569 |
| 2004q4 | £120,859 | £120,401 | £120,779 | £120,601 |
| 2005q1 | £122,827 | £122,701 | £122,146 | £121,684 |
| 2005q2 | £125,374 | £125,560 | £124,108 | £123,229 |
| 2005q3 | £124,488 | £124,958 | £122,249 | £121,843 |
| 2005q4 | £118,357 | £119,195 | £117,983 | £117,964 |
| 2006q1 | £123,483 | £123,893 | £123,831 | £123,457 |
| 2006q2 | £126,609 | £126,630 | £125,459 | £125,044 |
| 2006q3 | £125,495 | £125,874 | £124,599 | £124,071 |
| 2006q4 | £128,510 | £128,936 | £127,265 | £126,999 |
| 2007q1 | £129,378 | £129,926 | £129,097 | £128,880 |
| 2007q2 | £134,523 | £134,804 | £134,112 | £134,031 |
| 2007q3 | £134,534 | £134,759 | £134,511 | £134,594 |
| 2007q4 | £133,202 | £133,282 | £133,536 | £133,203 |
| 2008q1 | £132,349 | £132,267 | £131,257 | £130,610 |
| 2008q2 | £129,700 | £130,023 | £128,062 | £126,736 |

# 04 Conclusions

The underlying theme of this analysis is that the implicit time on the market, the overhang of unsold houses relative to the rate at which houses are selling triggers two processes. It is used by both by sellers as a guide as to how long they should hold out for a better price, and also by prospective buyers and sellers to adjust their perception of the distribution of valuations. The results are consistent with the theory and both effects are significant at the 5 per cent level in a one-tail test. The estimated first effect may be understated because the quarterly price data used were average prices for each quarter, while the independent variables were the second month values of each quarter. In addition, the adjustment time frame may differ from the quarterly data used in the analysis.

Two results fall out of this model. First, the practical point that the model cannot provide the correct time unit for perceptions to alter – the theory does not indicate whether it should be one week, one month or three months. This is an empirical issue that would require investigation – this calibration would provide a much sharper focus. There may be data issues involved here. Second, once fully calibrated, the model provides:

1. the current deviation of actual price from the long-run equilibrium price, the difference being due to working off excess (insufficient) inventory of unsold houses that is altering the expected waiting time per bid
2. the direction and amount by which the distribution of valuations is changing over time
3. the extent of the disequilibrium, that is, the deviation between long run equilibrium time on the market, implied time on the market, and actual time on the market.

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