CYCLES IN THE PRICE ELASTICITY OF DEMAND FOR HOUSING

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It has become clear over the past decade, from studies such as Carruth and Henley (1990) and Maclennan (1994), that the influence of cycles in housing demand extend well beyond the boundaries of the housing sector. Maclennan op cit, for example, has argued that the duration of a macro slump may be determined by *inter alia* the volatility of the housing market. Since a large proportion of household expenditure is used to purchase housing, and since the price elasticity of demand (PED) determines how housing consumption changes as prices change (which feeds back into the determination of house prices), it can be seen even from a cursory examination, how PED can influence household consumption and the macro economy. Caruth and Henley have further shown that the escalation of house prices during a boom and the resulting rise in equity withdrawal can profoundly affect consumption and saving rates generally. The volatility of house prices and the determination of housing demand is therefore of general economic interest.

In this paper I aim to show that a key determinant of house price volatility is the PED and that this parameter may itself be cyclical and may have a crucial role in the adjustment to equilibrium price. The central thesis is that PED is contingent upon the number of effective close substitutes available to the purchaser at the point of the consumption decision, and this number will fluctuate over the housing cycle depending on the total number of dwellings on the market, the expected time on the market of each dwelling, and consumer search efficiency. Because the number of dwellings on the market increases during boom periods along with the corresponding probability of finding a substitute dwelling at lower cost, one would expect the price elasticity of demand to increase substantially during booms. However, the extent to which PED can increase during booms is constrained by the probability that a dwelling will leave the market before the consumer has viewed all other dwellings contemporaneously for sale. Because time on the market diminishes during boom periods, there will be a countervailing force to the rising housing demand elasticity. This provides a possible explanation for the low ceiling on housing demand elasticity found in empirical studies. Moreover, the demand elasticity during boom periods may constitute a measure of market efficiency, reflecting search capacity constraints faced by purchasers in a particular market. The income elasticity of demand may also vary over the housing cycle due to the cyclical nature of credit rationing: lenders offer greater income multiples during boom periods.

The main contributions of the paper are that it:

(1) provides a theory of why PED and IED might vary over time and considers the implications for the volatility of the housing cycle;

(2) explains how the variation of PED and its sensitivity to market fundamentals might constitute a measure of market efficiency;

(3) provides a rationale for why demand will be more elastic the greater the level of dwelling heterogeneity;

(4) offers the insight that movements in relative marginal prices of characteristics may be crucial in determining PED (and so provides support for the estimation of separate hedonic price equations for each period and region);

(5) consistent with this insight, time specific estimates of hedonic prices are used (a separate price equation is estimated for each quarter and each region over a twenty year period);

(6) offers the first estimates of the movements of PED and IED over the economic cycle (these estimates are based on large sample regression analysis in each year – over 4,400 observations on average). It is found that the price elasticity of demand does indeed have a strong cyclical element over the period 1981 to 1995 inclusive, but never rises above 0.7 in absolute terms;

(7) gives estimates of market efficiency (defined in terms of price search capacity and information efficiency) by calibrating the sensitivity of PED to real hedonic price movements.

(8) finds some evidence that credit rationing bites most severely during slumps (i.e. lenders revise down their expectations of the borrowers appropriate income multiple more rapidly than the borrowers do).

1 Literature Review

A fairly large literature now exists on the estimation of the price elasticity of demand for housing, much of it concerned with correctly defining the price term. This is a less than straightforward issue because of the heterogeneous nature of housing as a commodity. A range of estimates exist, from –0.35 (Ermisch et al, 1996) to –0.5 (King, 1980); the discrepancies generally explained in terms of incorrect treatment of taxation of owner occupied housing, the net effect of local taxes, the role of expected capital gains, and due to variation in consumer behaviour between different tenure income and demographic groups and variations in time-lags in the adjustment of household consumption (Ermisch et al op cit p. 67, Rothenberg et al 1992, p. 20). A key omission to the usual list of explanations for the variation of price elasticity of demand is the possibility that it has a strong cyclical element due to variation in the number of available close substitutes which is contingent upon the number of dwellings on the market, the expected time on market, and the efficiency of the search process. Whilst the cyclical nature of the price elasticity of housing supply has been considered in the literature – cf. Pryce 1999 – no study has examined the cyclical nature of the PED. It is this explanation which forms the core theme of the paper and provides an explanation for why the 'net result of a very considerable body of research … appears to be a consensus that, overall, housing demand elasticities with respect to price … are significantly less than one in absolute value' (Rothenburg op cit p. 20).

The empirical component of the paper falls very much within the 'composite commodity' stream of housing demand literature rather than the steam which focuses on demand for individual attributes. One of the insights that emerges from the paper, however, is that sound construction of the price variable has to take into account changes to the individual coefficients on attributes since these relative movements are key to the pattern of preferred substitutes as the composite price changes. It should also be noted that although estimates of the price elasticity of demand (PED) are calculated for successive years, the paper falls within the cross-sectional stream of demand estimation (typified by Gibb and Mackay 2000, Ermisch et al op cit, King op cit), as opposed to the use of aggregate time series estimation (Meen, 1992).

2 Theory of Housing Demand for First Time Buyers

2.1 Intuitive Summary

It is worth stating, at the outset, that the analysis is restricted to the examination of first time buyers (FTB) and/or those who either do not currently own a home or whose purchase decision is not contingent upon the sale of his/her property. This restriction is introduced in order to remove the complications incurred by the simultaneity of the selling and purchasing decision of existing owner occupiers. The tenure choice decision is assumed to be exogenous: or in the parlance of the theory presented here, rented housing is not considered to be a 'close effective substitute': FTBs are assumed to have already chosen to leave rented accommodation and the only decisions remaining for them relate to the purchase of a suitable dwelling.

Having identified the decision makers we are interested in and the nature of the decisions we wish to analyse, let us turn now to the question of the determination of the price elasticity of demand. In traditional economic theory, the price elasticity of demand is said to be determined by the closeness of substitutes. Thus, the demand for food as a whole is highly inelastic (since there are no substitutes), whereas the demand for particular brands of certain types of food is likely to be relatively elastic. The theory put forward in this section is the hypothesis that the substitutability of a particular dwelling will be driven *inter alia* by the expected time on the market of dwellings currently for sale, and so the substitutability (and hence PED) will vary with housing cycles.

The rationale behind this hypothesis is as follows: purchasers (particularly first time buyers) do not have perfect information regarding all dwellings for sale, and so buying a house entails a search process. The buyer begins this search process by examining dwelling A, which has a given set of characteristics and price. In order to decide whether or not this is a good purchase, the buyer seeks to examine further dwellings B, C, …., Z which lie in the same price range. The price elasticity of demand is assumed to be determined by the price and availability of known substitutes. Thus, the more dwellings the buyer can survey and choose from, the more effective substitutes there are available to him, and the more sensitive he is to price. Therefore, if there exists a constraining factor which limits the number of dwellings he can survey, or which increases the cost of surveying further dwellings, then the effect of this factor will be to dampen the price elasticity of demand.

One such factor is the time on the market of dwellings that the buyer has surveyed (i.e. the probability that someone else will purchase the property during the time that it takes to survey further properties). During boom periods, the average time on market substantially declines and so buyers have to take into account the possibility that the first dwelling they surveyed may no longer be on the market by the time they have surveyed further dwellings.

A countervailing factor, however, is that during housing slumps, the fact that there is less turnover (and possibly negative equity) means that there will be less dwellings on the market over a given period, even though at any specific point in time, the number of houses for sale may be more because of the reduced time-on-market (TOM). Thus, the number of effective substitutes (ES) that a purchaser has to choose from (taking into account search times and the fact there is a strict sequence to dwelling viewing given that one cannot view two dwellings simultaneously) is likely to increase rapidly as the boom weakens and TOM increases; ES will then plateau as fewer dwellings actually come onto the market, and eventually even decline as negative equity kicks in.

At the same time, we need to consider the effect on the optimum number of dwellings for viewing and on the total search time, of anticipated movements in prices. For example, if prices are rising fast, it may be optimal to buy quickly and view fewer properties. So this may show up as price inelasticity for the individual buyer, when in fact he/she is price sensitive (i.e. sensitive to expected price changes).

2.2 Formal Model

Through a process of viewing properties within his/her price range (P_{B1}, P_{B2}) a purchaser b (who either does not currently own a home or whose purchase decision is not contingent upon the sale of his/her property) arrives at a set of effective substitutes $\underline{D}^c$. Assume that the purchaser chooses a dwelling from choice set $\underline{D}^c$ on the basis of greatest utility relative to price (or 'average utility'):

$$\max_{z_i}(u(z_k)/\mathrm{P}_k,$$

where $z_k = \Sigma g_a A_a$, A_a is the list of dwelling attributes and g_a are the scalars that measure the quantity of each attribute. Let z^* be the property in $\underline{D}^c$ which offers greatest average utility to buyer b:

$$z^* = \{z_k\text{:}\ \bar{u}(z_k) > \bar{u}(z_j)\ \forall\ k,j \in \underline{D}^c\}$$

where $\bar{u}(z_k) = u(z_k)/P_k$. Because z^* offers the greatest utility under the current price regime, b's housing expenditure would be P^*, the price of dwelling z^*, provided there are no price changes before the purchase decision is finalised. An estimate of the amount of housing service consumed under this scenario is given by the market valuation of the quantity of housing consumed relative to $\hat{P}$, the market valuation of a standardised housing unit:

$$\text{Housing Consumption (HC)} = \mathrm{P}^* / \hat{P}$$

Now assume the market valuation of housing services increases from $\hat{P}$ to $\hat{P}'$ such that:

$\hat{P}' = (1+\alpha)\ \hat{P}$.

For sake of argument, this results in an increase in the market valuation of z^* from P^* to $P^{*\prime}$ where:

$P^{*\prime} = (1+\alpha)P^*$,

where $P^{*\prime} \in \underline{P}^B$, the set of prices which fall within the buyers price band. The purchaser has to decide whether or not to go ahead with purchasing z^* and this will depend upon whether there are any alternative dwellings in $\underline{D}^c$ which offer greater utility relative to price under the new price regime.

If not, and z^* remains optimal, then:

$$HC' = P^{*\prime}/\hat{P}' \quad = (1+\alpha)\, P^* / (1+\alpha)\ \hat{P}$$
$$= HC.$$

Thus, ΔHC due to the price change is zero, and the price elasticity of demand (PED) is zero (i.e. demand is perfectly inelastic).

Now consider the possibility that there is another dwelling, $z_k \in \underline{D}^c$ which does indeed offer greater utility relative to price than z^* under the new price regime:

$$u(z^*)/P^* > u(zk)/P_k' > u(z^*)/P^{*\prime}$$

Since $u(zk)/u(z^*)$ has remained constant, $P_k'/P^{*\prime} < P_k/P^*$. In other words, the price of z^* has increased relative to the price of z_k and so,

$$HC' = P_k'/\hat{P}'$$

But since $\hat{P}$ also increased by α, the price of z_k must have fallen relative to the market valuation of the standardised housing unit, and so HC has fallen and PED < 0. Thus, we have shown how the PED is contingent upon the existence of substitutes which offer greater average utility at a lower level of HC under the new price regime.

<u>Proposition 1:</u> Assuming the choice set $\underline{D}^c$ is random, the larger the choice set (i.e. the more dwellings there are in $\underline{D}^c$) the larger the likely fall in HC as prices rise (and hence the larger the likely demand elasticity).

If P^* (as defined above) rises to P^{*}', where P^*, P^{*}' $\in \underline{P}^B$, and if the average utility of z^* falls from $\bar{u}^*$ to $\bar{u}^{*}$', then there is a probability p_s that there exists z_k such that $P_k'/\hat{P}' < P^*/\hat{P}$ and $\bar{u}_k > \bar{u}^{*}{}'$ (i.e. there exists a dwelling that is preferable when prices rise and whose purchase will imply a fall in *HC* when prices rise). Let D^c be the number of dwellings in $\underline{D}^c$. Proposition 1 says that p_s increases as D^c increases. This can be seen by example. Let p_k = Prob($P_k'/\hat{P}' < P^*/\hat{P}$ and $\bar{u}_k > \bar{u}^{*}{}'$). If $D^c = 1$, $p_{s:Dc=1} = 0$. If $D^c = 2$, $p_{s:Dc=2} = p_1 + p_2 - p_1p_2$. If $D^c = 3$, $p_{s:Dc=3} = p_1 + p_2 + p_3 - p_1p_2 - p_2p_3 - p_1p_3 + 2p_1p_2p_3$. Clearly, $p_{s:Dc=1} < p_{s:Dc=2} < p_{s:Dc=3} \Rightarrow p_{s:Dc=j} < p_{s:Dc=j+1}$ since each additional dwelling can only bring an additional chance (however small) that there exists a dwelling k in $\underline{D}^c$ such that $\bar{u}_k' > \bar{u}^{*}{}'$ that has $P_k'/\hat{P}' < P^*/\hat{P}$. Summed across buyers, the greater the average p_s the greater the market PED at a given point in time. Thus,

$$p_s = p_s(D^c, \text{Prob}(\bar{u}_k' > \bar{u}^{*}{}'))$$

where $\partial p_s/\partial D^c > 0$.

It should be noted that the PED will depend not only the probability that there exists a single dwelling k such that $\bar{u}_k' > \bar{u}^{*}{}'$, but also on the related variable, that of the number of dwellings that satisfy this criteria. The more dwellings that satisfy $\bar{u}_k' > \bar{u}^{*}$', then the more chance that one of those dwellings will incur a substantial fall in HC (the proof follows the same logic as that given above).

Proposition 2: *The greater the heterogeneity of dwellings ceteris paribus, the greater the value of ps.*

First note that holding the number of dwellings in D^c constant for a given utility distribution $u_b(z_k)$, p_s depends on Prob($\bar{u}_k' > \bar{u}^{*}$') because if,

$$p_s = \text{Prob}\{\ P_k'/\hat{P}' < P^{*}/\hat{P} \text{ and } u(z_k)/P_k' > u(z^{*})/P^{*}' \text{ given that uk/Pk} < u^{*}/P^{*}\}$$

and if all dwellings are identical, then $u_k = u^{*}$ (where $u_k = u(z_k)$) and the valuation would be identical, both at the old prices, $P_k = P^{*} = \hat{P}$, and the new prices, $P_k' = P^{*}' = \hat{P}'$. Therefore, $HC' = P^{*'}/\hat{P}' = 1 = HC \Rightarrow \Delta HC = 0$.

Now let us introduce heterogeneity of dwelling characteristics by defining it as the sum of squared deviations from the mean magnitude of characteristic x relative to the hedonic price $\hat{P}$:

H_k = Variance of Characteristics for Individual Dwelling $= \sum_{x,y}((\gamma_{xk}/P_k) - (\bar{\gamma}_x/\hat{P}))^2$

H_M = Variance of Characteristics for Whole Market $= \sum_k \sum_{x,y}((\gamma_{xk}/P_k) - (\bar{\gamma}_x/\hat{P}))^2$

Complete homogeneity therefore entails $H_k = 0$ and $H_M = 0$. Some degree of market heterogeneity exists if $H_M > 0$. If the relative heterogeneity of dwellings in $\underline{D}^c$ is large, then there is more chance that there exists a dwelling k that faces a proportional price increase different to the percentage change in price of the initially optimal dwelling (i.e.$(P_k'/P^{*'}) < (P_k/P^*)$) for linear hedonic equations except where the change in hedonic price is due equal proportionate changes to all market marginal valuations of characteristics. This can be seen from the following linear hedonic price equation,

$$\hat{P} = \beta_0 + \beta_1 \bar{\gamma}_1 A_1 + \beta_2 \bar{\gamma}_2 A_2 + \ldots + \beta_X \bar{\gamma}_X A_X \text{, where } x = 1, 2, 3, \ldots X.$$

If the $\Delta\hat{P}$ is arises from a change in β_x, the underlying marginal valuations of characteristics, then deviations from $\bar{\gamma}_x$ will produce different percentage changes in P_k relative to $\%\Delta\hat{P}$. For sake of argument, assume the opposite. Let there be a proportionate change, α, to one of the marginal prices only,

$$\hat{P}' = \beta_0 + (1+\alpha)\beta_1 \bar{\gamma}_1 A_1 + \beta_2 \bar{\gamma}_2 A_2 + \ldots + \beta_X \bar{\gamma}_X A_X$$

The change in hedonic price is then given by,

$$\hat{P}' - \hat{P} = (1+\alpha)\beta_1 \bar{\gamma}_1 A_1 - \beta_1 \bar{\gamma}_1 A_1 = \alpha\, \beta_1 \bar{\gamma}_1 A_1$$

This increase in the valuation of characteristic A_1 results in a change in price for both the preferred dwelling under the old price regime, z^*, and for z_k, where $z^*, z_k \in \underline{D}^C$,

$$\Delta P_k = P_k' - P_k = \alpha\, \beta_1 \gamma_{\kappa 1} A_1$$

$$\Delta P^* = P^{*'} - P^* = \alpha\, \beta_1 \gamma^*_1 A_1$$

Now if we assume that ratio of P_k and P^*, to $\hat{P}$ do not change when there is an increase in the marginal valuation of A_1,

$$P_k' / P^{*'} = P_k / P^*,$$

$$\Rightarrow \quad (P_k + \Delta P_k)/ (P^* + \Delta P^*) = (P_k + \alpha\, \beta_1 \gamma_{\kappa 1} A_1) / (P^* + \alpha\, \beta_1 \gamma^*_1 A_1) = P_k / P^*$$

$$\Rightarrow \quad P^* (P_k + \alpha\, \beta_1 \gamma_{\kappa 1} A_1) = P_k (P^* + \alpha\, \beta_1 \gamma^*_1 A_1)$$

$$\Rightarrow \quad \gamma^*_1/P^* = \gamma_{\kappa 1}/ P_k \qquad [1]$$

$$P^{*'} / \hat{P}' = \quad (P^* + \Delta P^*) / (\hat{P} + \Delta \hat{P}) = (P^* + \alpha \beta_1 \gamma^*_1 A_1) / (\hat{P} + \alpha \beta_1 \bar{\gamma}_1 A_1)$$

$$\Rightarrow \quad \bar{\gamma}_1 / \hat{P} = \gamma_1^* / P^*$$

$$P_k' / \hat{P}' = \quad (P_k + \Delta P_k) / (\hat{P} + \Delta \hat{P}) \quad = \quad (P_k + \alpha \beta_1 \gamma_{\kappa 1} A_1) / (\hat{P} + \alpha \beta_1 \bar{\gamma}_1 A_1)$$

$$\Rightarrow \quad \gamma_1 / \hat{P} = \gamma_{\kappa 1} / P_k,$$

then we end up with the following:

$$\Rightarrow \quad \gamma^*_1 / P^* = \gamma_{\kappa 1} / P_k \quad = \quad \bar{\gamma}_1 / \hat{P} = \gamma_1^* / P^* \quad = \quad \bar{\gamma}_1 / \hat{P} = \gamma_{\kappa 1} / P_k$$

This threefold equality implies complete homogeneity of dwelling characteristics which contradicts the assumption of heterogeneity defined as $H_M > 0$.

Heterogeneity combined with less than uniform changes marginal prices of characteristics therefore implies inequalities between percentage changes of hedonic prices relative to the percentage change in the hedonic price. The more heterogeneous the dwellings, the greater the inequality, and the greater the variation in P_k' that $(1 + \alpha)$ will cause between $P^*/P^{*'}$ and P_k/P_k', and so the greater the scope for finding a dwelling k such that u(zk)/Pk' > u(z^*)/P^*' even though uk/Pk < u^*/P^*.

Another implication of this analysis is that movements in the relative values of marginal valuations are an important determinant of the price elasticity of demand. For the empirical analysis to be consistent with this theory, the estimation of the hedonic price equation must allow for variation in the estimated parameters over time (i.e. for $\hat{\beta}_1$ to vary relative to $\hat{\beta}_2$ etc.). Simply including time dummies (as in Gibb and Mackay op cit, Ermisch et al op cit etc.) is inadequate since it still assumes the coefficients are constant and therefore overlooks an important source of variation in PED.

The special case where $\%\Delta P_k = \%\Delta \hat{P}$ even when there are heterogeneous characteristics is when $\Delta\beta x = \Delta\beta_y \; \forall \; x,y \in X$: Let $\hat{P} = \beta_0 + \beta_1 \bar{\gamma}_1 A_1 + \beta_2 \bar{\gamma}_2 A_2 + \ldots + \beta_X \bar{\gamma}_X A_X$ as before and let $\hat{P}' = (1+\alpha)\,\beta_0 + (1+\alpha)\,\beta_1 \bar{\gamma}_1 A_1 + (1+\alpha)\,\beta_2 \bar{\gamma}_2 A_2 + \ldots + (1+\alpha)\beta_X \bar{\gamma}_X A_X$. Then,

$$\Delta \hat{P} = \hat{P}' - \hat{P}$$

$$= \alpha\, \beta_0 + \alpha\, \beta_1 \bar{\gamma}_1 A_1 + \alpha\, \beta_2 \bar{\gamma}_2 A_2 + \ldots + \alpha\, \beta_X \bar{\gamma}_X A_X.$$

Thus, $\Delta \hat{P} = \alpha \hat{P}$ and $\%\Delta \hat{P} = \alpha \hat{P} / \hat{P} = \alpha$. Similarly for P_k, under the new price regime, $P' = (1+\alpha)\,\beta_0 + (1+\alpha)\,\beta_1 \gamma_{k1} A_1 + (1+\alpha)\,\beta_2 \gamma_{k2} A_2 + \ldots + (1+\alpha)\beta_X \gamma_{kX} A_X$, and $\Delta P_k = P_k' - P_k = \alpha P_k$. Therefore, $\%\Delta \hat{P} = \%\Delta P_k = \alpha$, irrespective of the relative quantities of dwelling characteristics in property *k*.

However, even if all hedonic price coefficients change uniformly, the changes in individual dwelling prices is unlikely to be exactly the same as the change in price of the standardised dwelling because of imperfect information regarding dwelling quality and characteristics. Thus, the price of an individual dwelling, P_k will contain an error term, u_k, which may not be independently and identically distributed (i.e. white noise). For example,

$$P_k = \beta_0 + \beta_1 \gamma_{k1} A_1 + \beta_2 \gamma_{k2} A_2 + \ldots + \beta_X \gamma_{kX} A_X + u_k$$

and

$u_k = u_k(\delta_k, \underline{V}^o, \varepsilon_k)$

where δ_k is the length of time the dwelling has been on the market (a possible signal of hidden negative quality), $\underline{V}^o$ is a vector of miscellaneous omitted variables, and ε_k independently and identically distributed. The existence of u_k opens the way for further heterogeneity and hence further scope for finding a preferred substitute following a price change.

Proposition 3: The relationship between price elasticity of demand and the number of dwellings on the market will be non-monotonic.

The preceding propositions have established the role of D^c, the number of dwellings in the borrower's choice set, in determining the price elasticity of demand. To summarise the argument so far, the larger the value of D^c the greater the number of effective substitutes, and the greater the probability in the event of a price rise that the borrower will find a lower priced dwelling that will be preferred to the previously optimal property under the old price regime. Until now, however, we have not considered the determination of D^c, and as we do so, it will become clear that it has a strong cyclical element, incurring a cyclical dimension to the price elasticity of demand.

The most obvious determinant of D^c_t will be D^{OM}_t, the number of dwellings on the market in the relevant geographical area. However, D^c_t and D^{OM}_t are not necessarily equivalent because search costs imply an optimal number of dwellings that a borrower will want to survey. Moreover, a second constraint may come into play (one that is perhaps unique to real estate markets) that of the expected time on the market. Searching incurs the consumption of time as well as a monetary resources, and as such, for every additional dwelling a consumer considers viewing, he/she has to take into account the probability that dwellings already viewed will be sold to other buyers before he/she has made a final purchase decision. Moreover, this probability will not remain constant over time for during boom periods the expected time on the market may be very short, in some areas less than a day, imposing a severe restriction on the number of dwellings that remain in the choice set at any one point in time.

A simple way to model this process is to say that the buyer starts and completes the search process within time period t, at the end of which he makes a final purchase decision. The number of effective substitutes he/she can choose between is equal to the number of dwellings on the market or the maximum number dwellings he/she can possibly view in time t (whichever is the lesser), less the proportion of dwellings which will have been sold to other purchasers. We can therefore define $D^c{}_t$ as,

$$D^c{}_t = \min[D^\#{}_t\,(1\text{-}s_t),\, D^B{}_t(1\text{-}s_t)]$$

where $D^\#{}_t$ is the maximum number of dwellings physically possible (or financially optimal, if there are search costs) to view in time t, s_t is the probability that a dwelling will have sold before the buyer makes a final purchase decision (likely to rise during housing booms and fall during slumps – see below), and $D^B{}_t$ is the total number of properties on the market in time t and in the appropriate price band. It should be noted that $D^\#{}_t$ may also not be static over the housing cycle but may be fall during boom periods if the search process is contingent upon market intermediaries -- estate agents, solicitors, surveyors etc. -- and if these intermediaries face capacity constraints during periods of high transactions volumes. Thus,

$$D^{\#}_{t} = D^{\#}_{t}(s_tD^{OM}_{t}, C_{bt}(s_tD^{OM}_{t}, I_{bt}))$$

where $s_tD^{OM}_{t}$ represents the volume of transactions in period *t,* and C_{bt} are search costs, which may also be vary with the volume of transactions since market intermediaries are likely to raise prices as they face capacity constraints. C_{bt} will also be determined by I_{bt} represents other factors determining *b*'s acquisition of information regarding dwelling characteristics. D^{OM}_{t} and D^{B}_{t} are closely related given that they are determined by the same price distribution ω_t of dwellings currently on the market,

$$D^{OM}_{t} = \int \omega_t dP ,$$

and,

$$D^{B}_{t} = \int_{P_{B1}}^{P_{B2}} \omega_t dP ,$$

where P_{B1} and P_{B2} are the lower and upper bounds of the borrowers price bracket.

In a multi-period search model, the choice set at a given point in time (assuming exogenous search duration) is given by the number of dwellings the borrower has been able to view from time = 0 to the current period *t* that are still on the market, subject to search constraints,

$$D_t^c = \min\left[\int_0^t D_t^{\#}(1-s_t)dt, \int_0^t D_t^{B}(1-s_t)dt\right] = \min\left[\int_0^t D_t^{\#}(1-s_t)dt, \int_0^t (1-s_t)\left(\int_{P_{B1}}^{P_{B2}} \omega_t dP\right)dt\right],$$

where $s_t = s_t(\Sigma_k \rho_k)$ indicates the dependence of s_t on the sum of contingent survival probabilities, where ρ_k is the probability that dwelling k is sold to another purchaser in time t given that the dwelling has been on the market for duration δ_k, and given the ratio of potential demand to potential supply. Thus,

$$\rho_k = \rho_k(\delta_k, n^b_t / D^{OM}_t),$$

where n^b_t is the number of potential buyers in time t.

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Because $\partial\rho_k/\partial D^{OM} < 0$, $\partial s_t^2 / \partial\rho_k \partial D^{OM} < 0$, $\partial D^{\#}_t / \partial D^{OM} < 0$; whereas $\partial D^B_t / \partial D^{OM} \geq 0$ and $\partial/\partial D^B\left(\int_0^t D^c_t \, dt\right) > 0$, it can be seen that $\partial/\partial D^B\left(\int_0^t D^c_t \, dt\right)$ has ambiguous sign. Given that

(i) the relationship between price elasticity of demand and D^c is monotonically positive, and (ii) the relationship between D^c and D^{OM} non-monotonic, we can conclude that the relationship between price elasticity of demand and D^{OM} is non-monotonic.

<u>Proposition 4:</u> *The PED will increase with heterogeneity of utility across purchasers.*

So far we have been ambiguous when we say D^{OM} increases whether n_{bt} (the number of potential buyers) increases at the same time. For if n_{bt} increases any effect on D^c of an increase in D^{OM} may be cancelled out if $\partial n^b_t / \partial t > D^{OM}_t / \partial t$. However, a crucial factor is the degree of heterogeneity of preferences which may mean that the number of expected substitutes (i.e. the number of substitutes multiplied by the probability of the dwelling not being purchased by another buyer) still increases when n_{bt} increases because we cannot say that $u_b(z_k) = u_{b+1}(z_k) \ \forall \ k$, b and so b will be able to signal his preference for a particular substitute (and reduce the chance of the dwelling being sold to another borrower) by bidding over the asking price by amount λ: $P_{bk}' = P_k' + \lambda_b$. To demonstrate this requires a different model formulation than what we have specified, but it can be seen intuitively that if there is no legal obligation to commit to an offer, the buyer can make several simultaneous bids on substitutes which are preferable under the new price regime. There still remains some probability $p_s\lambda$ that $P_{bk}'/\hat{P}' < P^*/\hat{P}$ and $u(z_k)/P_{bk}' > u(z^*)/P^{*}{}'$. This probability will still be positively related to D^{OM} and final property allocation will follow some sort of tatonnement process.

<u>Proposition 5:</u> *The price elasticity of demand during booms reflects market efficiency.*

The case for considering the price elasticity of demand during booms as a measure of housing market efficiency arises from the effect of constraining factors on PED during booms; namely, the determinants of the search capacity constraint $D^{\#} = D^{\#}(s_t D^{OM}{}_{t}, C_{bt}(s_t D^{OM}{}_{t}, I_{bt}))$. We have proffered that $D^c{}_t$, the set of effective substitutes in a given period, is given by the minimum of (i) the number of dwellings on the market in the buyers price range and (ii) the search capacity constraint. As Figure 1 shows, $D^c{}_t$ will rise with the number of dwellings on the market until the search capacity constraint $D^{\#}$ is reached, from which point onwards, any rise in $D^B{}_t$ will have no effect on $D^c{}_t$. Given that PED is a direct function of $D^c{}_t$, it can be seen that as $D^B{}_t$ rises, PED will similarly peak and level off. This would perhaps explain the fairly low ceiling on PED in the existing empirical literature. However, if s_t and $D^{\#}{}_t$ do in fact vary over the housing cycle as the preceding theory suggests, then it is conceivable that $D^c{}_t$ (and hence PED) may actually decline beyond some value of D^{B}_{t}, as Figure 2 shows, or that $D^{\#}_{t}$ initially rises with D^{B}_{t}, causing PED to gradually taper rather than abruptly level off (Figure 1).

For our purposes, upswings in the housing market are defined as periods when both prices and the volume of transactions are rising, due to the demand for dwellings increasing at a faster rate than the supply of dwellings (i.e. $\partial n^{b}_{t}/\partial t > 0$; $D^{OM}_{t}/\partial t > 0$; and $\partial n^{b}_{t}/\partial t > D^{OM}_{t}/\partial t$). If the price elasticity of demand is able to rise unconstrained with D^{OM}_{t} during boom periods, then the price rise necessary to return the market to equilibrium will be less than if PED is constrained by search limitations. For a given level of excess demand, *QsQd*, the price adjustment to equilibrium will be determined by the elasticity of demand. If there are successive shifts in demand over the boom period, each producing temporary excess demand, then the demand elasticity will have a cumulative impact on the final equilibrium price. Moreover, if the demand shifts reduce the expected time on market of dwellings, and PED increases by successively smaller amounts, then there may be an absolute maximum for the value of PED for a given level of market efficiency (defined in terms of search efficiency and the efficiency of market intermediaries) which will remain unmoved (and even decline) even in the face of extreme expansions of demand. Housing markets with higher values of PED during periods of rapid expansion may be considered more 'efficient' in the sense that the search process is less hampered by falling time on the market and intermediaries facing capacity constraints.

One possible way of using PED to gauge search efficiency would be to compute the proportionate increase in PED relative to the proportionate increase in the standardised house price:

$$\eta = \%\Delta\text{PED}/\%\Delta\hat{P}$$

or to compare the velocity and acceleration of PED with those of $\hat{P}$ during an upswing:

Compare Velocity: $\partial\text{PED}/\partial t$ and $\partial\hat{P}/\partial t$

Compare Acceleration: $\partial^2\text{PED}/\partial t^2$ and $\partial^2\hat{P}/\partial t^2$

Although both approaches incur considerable data requirements, the latter is far more onerous, in that PED would have to be calculated for sufficient time periods to provide enough observations to run a regression of PED against time.

Figure 1 Number of Effective Substitutes as the Number of Suitable Dwellings on the Market Increases: The Case where $D^{\#}$ and s are Constant Over Time.

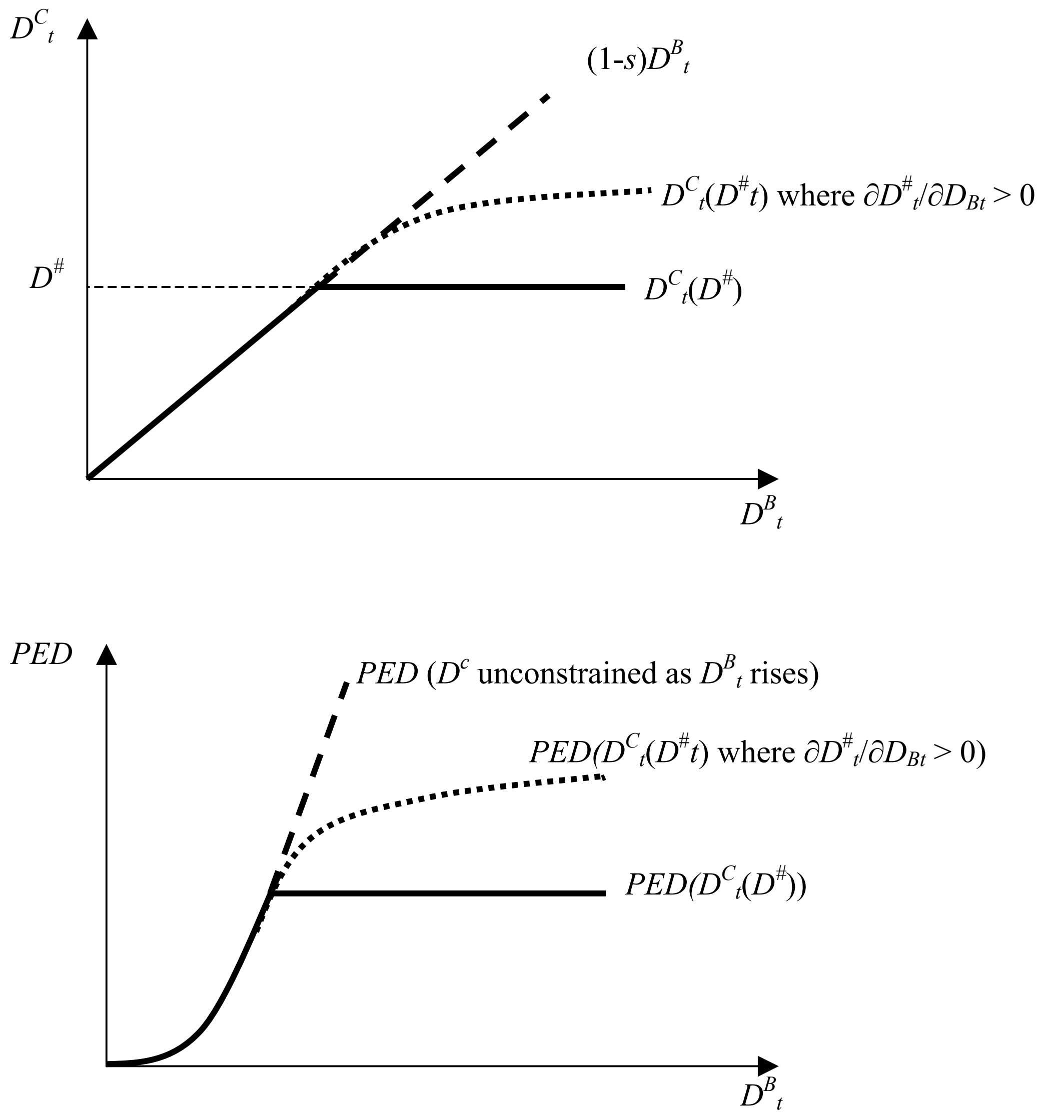
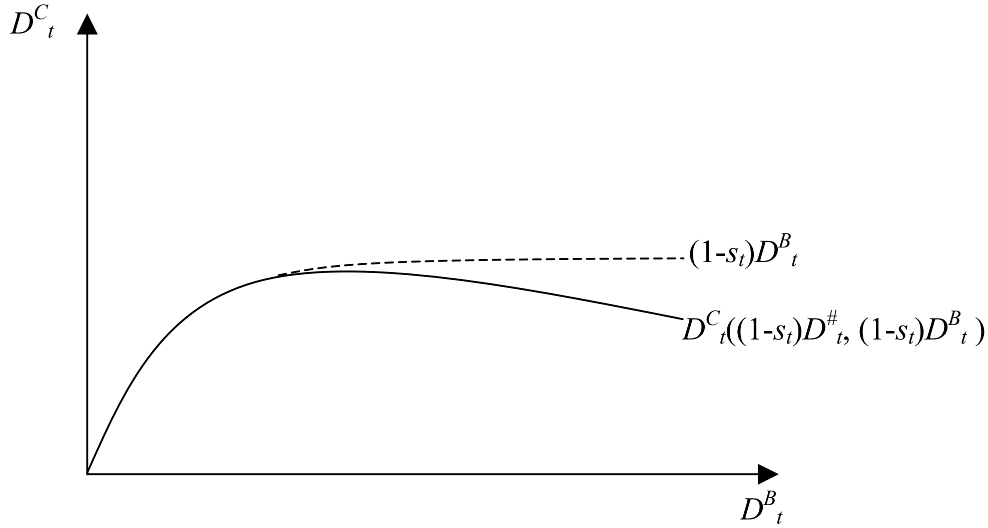


Figure 2 Number of Effective Substitutes as the Number of Suitable Dwellings on the Market Increases: The Case where $D^{\#}$ Falls and s Rises During Booms.



2.3 Income Elasticity of Demand

Although the main focus in this paper is the PED, a by-product of the empirical analysis is the first time-series of estimates of the IED, and so it is worth considering why IED might vary over time. The most obvious explanation are changes to the loan income multiples. Assume for the moment that *HC* is entirely determined by income. Let g_{tb} be the maximum income multiple the lender will offer borrower *b*, and let ψ_b be the borrower's preferred income multiple. Then, even if ψ_b is constant over time, the responsiveness of *HC* to changes in income will be time-dependent if g_{tb} varies because,

$$\text{HC} \quad = \quad \min[g_{tb}Y_b,\ \psi_b Y_b],$$

where Y is income. g_{tb} will be based on the lender's anticipation of *b*'s future creditworthiness, $g_{tb} = g_{tb}(Y_b$, Age of *b*, past savings history of b, expected capital gains) and since these arguments can vary over time, it is likely that g_{tb} will be time variant. Moreover, the borrower's housing consumption decision and optimal loan to income multiple may also vary over time, depending *inter alia* on the borrower's own perception of his/her future default risk. Thus, ψ_{tb} may be driven by a similar set of determinants as g_{tb}.

In order to isolate the underlying IED, variations in the predicted loan to income ratio has to be included. The extent to which the credit constraint bites will be revealed by whether controlling for changes in predicted loan to income ratio cause IED to increase by any significant amount. The greater the increase in IED when the predicted loan-to-income ratio (LTY) is included, the more the credit constraint bites.

3 Methodology

3.1 Data

Council of Mortgage Lending data, which formed the basis for the bulk of the empirical research presented below, is a well established as a reliable data set and has been used widely in aggregate time series analysis (Meen, various years). However, the cross sectional properties of the full data set has so far been overlooked and so this is the first study to fully utilize the 30,000+ observations collected in each year of the data set since 1974. The data is based on bank and building society mortgage transaction records submitted to the CML on an annual basis and includes information on month in which transaction complete, house type, age, number of rooms, price, mortgage advance, rate of interest charged, region, income and age of borrower.

The aim of the empirical analysis is to estimate price and income elasticities for each year from 1981 to 1995 using cross sections on each year. The time series properties of the data, however, mean that we can provide a robust in-sample estimate of the expected capital gains, which has alluded previous UK demand elasticity studies (such as Ermisch et al op cit and Gibb and Mackay et al op cit) which have utilised survey data collected in a single time period (these studies thus face severe data reliability problems regarding data on dwellings purchased more than a few years before the time of the survey, although Ermisch et al use only recent movers to minimise this problem). The large number of observations in each period also allow us to run separate hedonic price regressions for each quarter for each of the two regions considered: London and the

South East. These two regions were selected on the basis that (i) Meen (1996) has shown that there is no such thing as a single UK housing market and so it is more robust to model price and demand on a regional basis, which the data permits; (ii) these two regions are known to have the strongest cyclical elements, providing the strong contrast between boom and bust needed to test for movements in PED.

3.2 Housing Demand Equation

The aim of the empirical analysis is to estimate the following demand equation,

$$HC_b = \beta_0 + \beta_1 MCH_b + \beta_2 Y_b + \beta_3 AGE_b + \beta_4 AGE_b^2 + \beta_5 CC_b$$

where *HC* is housing consumption, *MCH* is the marginal cost of housing, *AGE* is the age of the main borrower, *CC* is the predicted credit constraint and β_i are the estimated coefficients. Household characteristics are not included, but this is unlikely to have been a major omission given that Ermisch et al (op cit, p. 75) found that 'an *F* test indicates that the household structure variables can be excluded'. Note also that no sample selectivity bias component is included, but this has been found to mainly affect IED (increasing its value by around 1.5) and to have only a marginal effect on PED (*ibid*). Since PED is our main concern in this paper, little is lost by not including such a component. As outlined in the theoretical model, *HC* is defined as,

$$HC = \text{House Price / House Price Index} = P^*_{bt} / \hat{P}_{rt}$$

where subscript *b* denotes the individual purchaser, and *r* denotes the respective region. Construction of the House Price Index was one of the most onerous elements of the analysis since it involved regressing house price on house characteristics (age of dwelling, age of dwelling^2, number of rooms, and building type) for each quarter for each region, using the estimated coefficients to predict the price of a standard house for that region in that quarter $\hat{P}_{rt}$.

The Marginal Cost of Housing was calculated along the same lines as Ermisch et al op cit,

$$MCH_b = UCC_b .(\hat{P}_{rt} / \text{RPI})$$

where RPI = monthly retail price index, and *UCC* is the user cost of capital, defined as:

$$UCC_b = (1\text{-}T)i_b + \delta + \alpha - \pi^*_{rt}$$

where:

T	=	HH's marginal income tax rate
i_b	=	mortgage rate faced by buyer
δ	=	depreciation
α	=	property tax rate
π^*_{rt}	=	expected rate of nominal house price change in each region.

The key variable here is the expected rate of nominal house price change which was estimated for each region separately on the assumption that expectations are backward looking (see Meen 1999). The variable was calculated by regressing $\Delta\hat{P}_{\text{rt}}$ on $\Delta\hat{P}_{\text{rt-1}}$ seperately for each of the two regions (r = 1,2).

$$\Delta\hat{P}_{rt} = \alpha_{0\text{r}} + \alpha_{1\text{r}}\,\Delta\hat{P}_{rt\text{-}1} + \varepsilon_{rt}$$

where $\Delta\hat{P}_{rt}$ is the four quarter difference in the price index, $\Delta\hat{P}_{rt} = \hat{P}_{rt} - \hat{P}_{rt\text{-}4}$. The regression results are given in Table 1. Estimates of $\alpha_{0\text{r}} + \alpha_{1\text{r}}$ were then used to forecast expected house price inflation from 1975 quarter one onwards for each region, $\hat{\pi}^*_{rt}$.

Following Ermisch op cit, *UCC* was then calculated assuming α and δ add up to 0.03 (constant), and T = basic income tax rate = 0.2,

$$UCC_b = (1+0.2)\, i_b + 0.03 + 0.3\ \hat{\pi}^*_{rt}$$

Because of the variation in credit rationing over the economic cycle, a proxy for the credit constraint faced by each individual borrower was introduced. The aim was to capture the maximum loan to income multiple for each borrower as decided by lenders'. Lenders decisions are assumed to be based on the borrowers past saving behaviour, income, age and the expected house price inflation. *CC* was thus calculated from predicted values from the following regression:

$$LTY_b = a_0 + a_1 Y_b + a_2 Y_b^2 + a_3 AGE_b + a_4 AGE_b^2 + a_5 STY_b + a_6 STY_b^2 + a_7 \hat{\pi}^*_{rt}$$

where LTY_b is the loan to income ratio recorded for b, and STY_b is the saving to income ratio. It should be noted, however, that risk averse borrowers are also likely to vary their preferred income multiples for the same reason that lenders do, and so this equation could be viewed as the reduced form of a simultaneously determined income multiple.

4 Results

Having calculated all the relevant components of the housing demand equation, regressions were then run on the pooled regional samples for each year from 1981 to 1995. Plots of the estimated PED and IED for each year are presented in Figures 5, 6, 7 and 8. Regression diagnostics are presented for boom and slump years in Tables 3 and 4 respectively. It can be seen that the adjusted R^2 varies between a quarter and two thirds, and has an average of 0.4, which is marginally stronger than the R^2 results reported by of Ermisch et al (average = 0.3). The strongest t-values (at least 32.5) are for current income in the regressions without a proxy for credit constraint. When the credit constraint is added, the t-values fall (to between 27 and 33). The MCH coefficients have more volatile t-values, being much less significant in slump years and between 6 and 12 in boom years. F-statistics (null hypothesis: $\beta_i = 0 \ \forall i$) for all regressions were highly significant. The average sample size for all years (1981-1995) was 4405.

It can be seen from the graphs that there is a strong cyclical component to PED with boom years having an average value of –0.477 compared with –0.058 for slump years. The PED never rises above 0.7 in absolute terms. The inclusion of the credit constraint proxy had little impact on the PED estimates, in contrast to the effect on IED which was quite substantial, making the estimates considerably more volatile, as Figures 7 and 8 show. Without the credit constraint variable, it can be seen that there is an upward trend in IED (probably due to the phased impact of financial deregulation which has caused loan income multiples to rise over time) and a small cyclical variation (probably due to cyclical component in income multiples offered by lenders and sought by borrowers). Notice also that the difference between IED with and without the credit constraint variable is considerably greater during slump periods (based on averages listed in Table 3 and Table 4, the difference during boom = 0.068; and the difference during slump = 0.335). This suggests that credit rationing bites most severely during slumps (i.e. lenders revise down their expectations of the borrowers appropriate income multiple more rapidly than the borrowers do).

A number of simple regressions are reported in Table 5 which estimate the sensitivity of PED to price as a means of gauging market efficiency. Each specification of the regression yields an elasticity of around 3. We cannot tell whether this is a relatively large figure (i.e. the London/South East markets are efficient) or small (i.e. not efficient) until figures on other markets or time periods have been computed. Comparison with other markets could also reveal the sensitivity of PED to heterogeneity of stock.

Table 1 Autoregressive House Price Change Model

Dependent Variable = $\Delta \hat{P}_{rt} = \hat{P}_{rt} - \hat{P}_{rt-4}$ = DPH4

	London	South East
Variable		
R^2	0.586	0.631
Adjusted R^2	0.581	0.626
F	109.070 [0.000]	131.401 [0.000]
N	79	79
Constant	508.584 (1.274)	169.140 (0.440)
DPH4_1	0.785 (10.444)	0.8512 (11.463)

Table 2 Credit Constraint Regression

Dependent Variable = Loan-to-Inome

Variable	Combined London & South East Sample
R^2	0.198
Adjusted R^2	0.196
F	104.631 [0.000]
N	2972
Constant	2.730 (26.781)
Income	-2.879E-05 (-17.273)
Income^2	1.048E-10 (6.579)
Age	.021013 (3.733)
Age^2	-3.905E-04 (-5.547)
Savings/Income	.216455 (5.221)
$(\text{Savings/Income})^2$	-.041652 (-3.296)
$\hat{\pi}^*_{rt}$ = Expected capital gain	.300122 (3.190)

Table 3 Regression Results for Boom Years:

Dependent Variable = Housing Consumption (Log)

	No Credit Rationing Assumed			*Credit Rationing Controlled For*		
Variable	**1987**	**1988**	**1989**	**1987**	**1988**	**1989**
R^2	0.327	0.381	0.339	0.333	0.380	0.339
Adjusted R^2	0.326	0.3805	0.338	0.333	0.380	0.338
F	661.814	803.720	535.398	545.676	640.282	427.844
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N	5466	5229	4182	5466	5227	4178
Constant	-1.033	-1.336	1.510	-3.352	-1.752	1.143
	(-3.253)	(-4.327)	(1.505)	(-7.539)	(-4.767)	(1.078)
Income (log)	0.510	0.528	0.525	0.674	0.560	0.533
	(44.576)	(46.772)	(39.166)	(27.035)	(29.382)	(23.772)
Marginal Cost of Housing (log)	-0.4223	-0.376	-0.653	-0.406	-0.378	-0.626
	(-12.326)	(-11.583)	(-6.258)	(-11.876)	(-11.651)	(-5.976)
Age	0.005	-0.014	-0.023	0.010	-0.013	-0.023
	(2.266)	(-6.120)	(-9.465)	(4.246)	(-5.011)	(-7.779)
Age^2	-0.1E-03	9.7E-05	0.2E-03	-0.1E-03	8.2E-05	0.2E-03
	(-4.783)	(3.436)	(8.023)	(-5.108)	(2.825)	(6.779)
Estimated Credit Constraint	–	–	–	0.506	0.083	0.016
	–	–	–	(7.414)	(2.237)	(0.330)
Average Boom PED		**-0.484**			**-0.470**	
Average Boom IED		**0.521**			**0.589**	
Overall Average Boom PED			**-0.477**			
Overall Average Boom IED			**0.589**			

Figures in parentheses are t-values
Figures in square brackets are significance levels

Table 4 Regression Results for Slump Years:

Dependent Variable = Housing Consumption (Log)

	No Credit Rationing Assumed			*Credit Rationing Controlled for*		
Variable	**1982**	**1992**	**1995**	**1982**	**1992**	**1995**
R^2	0.252	0.453	0.541	0.253	0.552	0.565
Adjusted R^2	0.251	0.451	0.541	0.252	0.550	0.565
F	421.878	283.183	868.497	338.750	336.750	766.464
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N	5013	1375	2951	5013	1375	2951
Constant	-4.116	-5.674	-6.394	-2.015	-14.879	-11.029
	(-12.225)	(-7.040)	(-47.668)	(-2.004)	-18.220	-28.738
Income (log)	0.432	0.684	0.659	0.431	1.304	1.041
	(32.820)	(32.433)	(54.645)	(32.826)	(32.218)	(32.528)
Marginal Cost of Housing (log)	0.001	-0.144	-0.058	-0.004	-0.061	-0.082
	(0.037)	(-1.976)	(-6.896)	(-0.115)	(-0.926)	(-9.766)
Age	0.012	0.003	0.018	0.025	0.019	-0.001
	(4.637)	(0.598)	(6.403)	(3.936)	(3.814)	(-0.439)
Age^2	-0.3E-03	-0.4E-4	-0.3E-3	-0.4E-3	-0.6E-6	0.5E-5
	(-7.749)	(-0.622)	(-7.922)	(-5.257)	(-1.005)	(1.252)
Estimated Credit Constraint	–	–	–	-0.250	2.097	1.458
	–	–	–	(-2.218)	17.380	12.844
Average Slump PED	**-0.067**			**-0.049**		
Average Slump IED	**0.591**			**0.926**		
Overall Slump PED	**-0.058**					
Overall Average Slump IED	**0.926**					

Figures in parentheses are t-values
Figures in square brackets are significance levels

Figure 3

Price Elasticity of Housing Demand Over Time

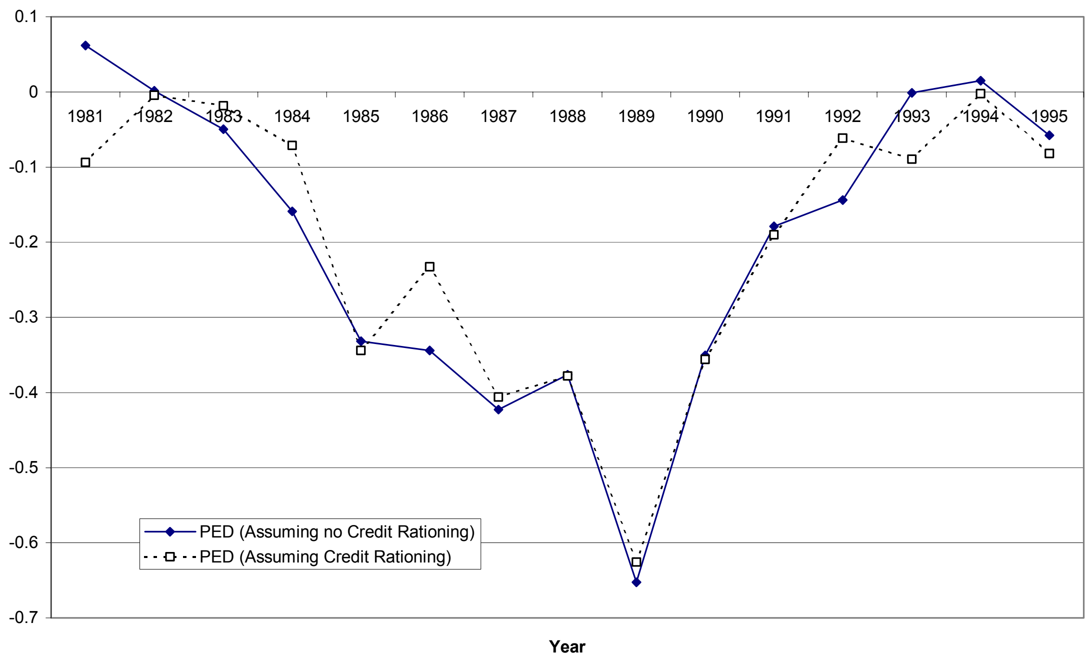


Figure 4

Absolute PED and Real Hedonic House Prices

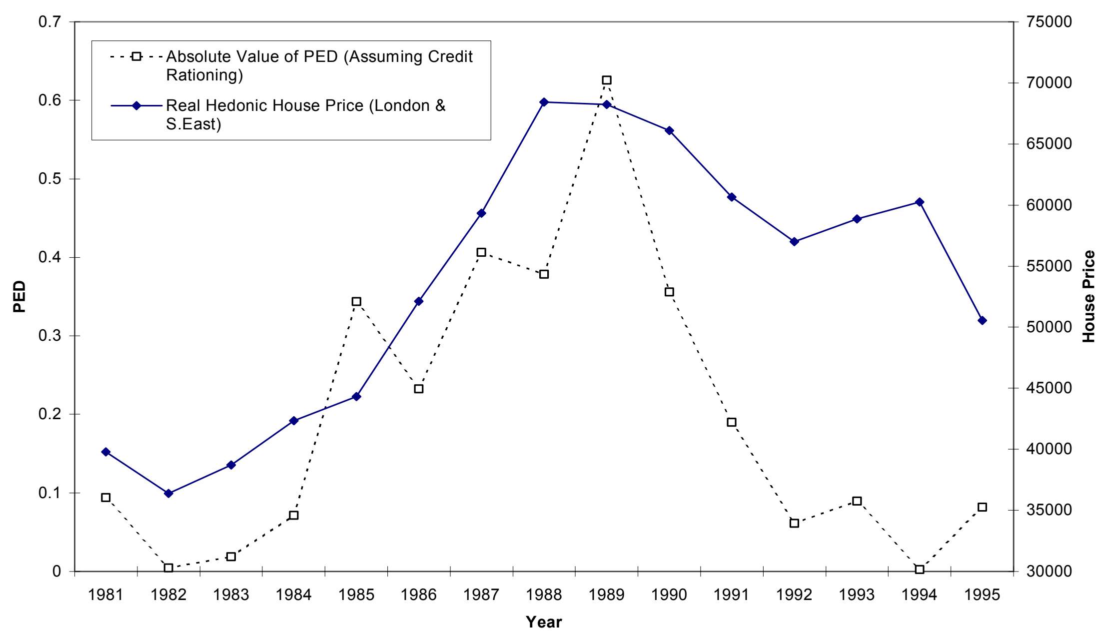


Figure 5

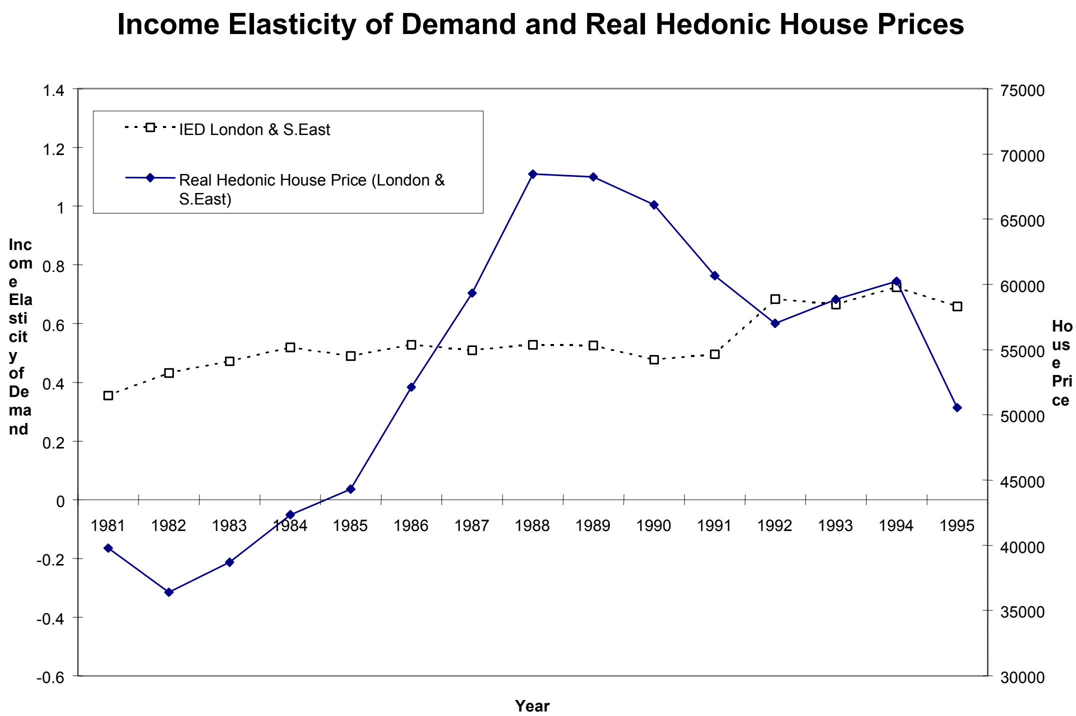


Figure 6

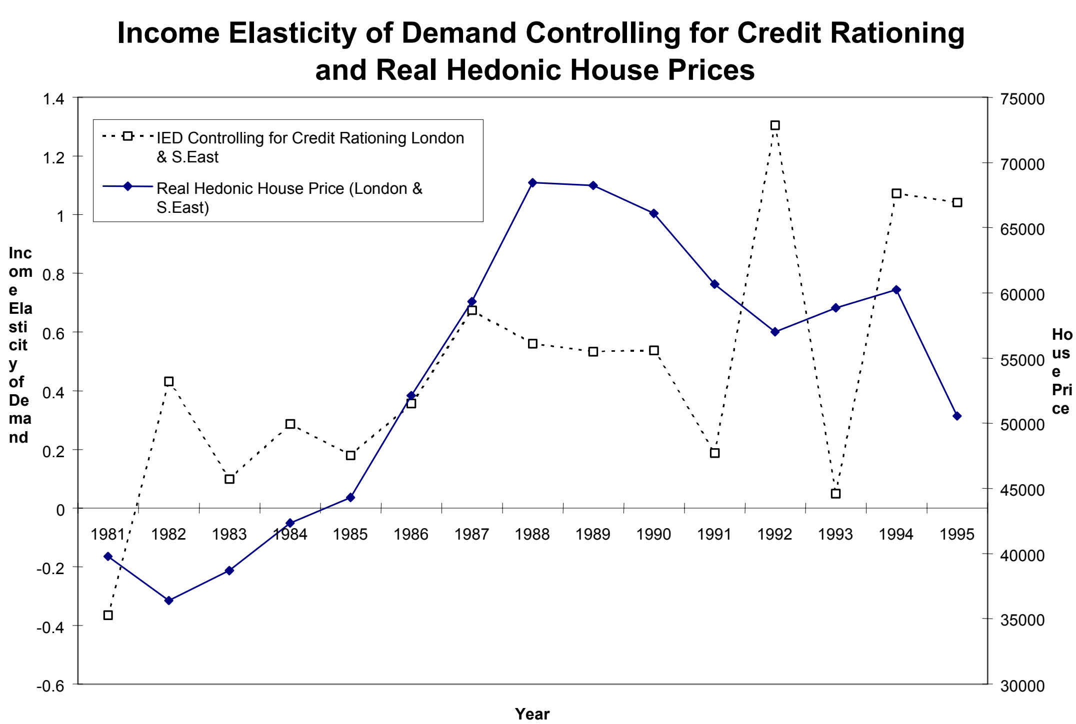


Table 5 Elasticity of PED with Respect to Price

Variables	Dependent Variable = PEDCR*	Dependent Variable = PEDCR*	Dependent Variable = PEDCR*
R^2	0.375	0.633	0.426
Adjusted R^2	0.327	0.355	0.382
F	7.794	8.696	9.65265
	[0.153]	[0.113]	[.008]
N	15	15	15
Constant	-0.358	-.106508	-.025
	(-1.767)	(-.969)	(0.767)
PHAT	1.037E-05	-	-
	(2.792)		
PHAT (log)	-	-	-
$PHAT^2$	-	1.019E-10	-
		(2.949)	
$PHAT^3$	-	-	1.293E-15
			(3.107)
Elasticity of PED with respect to price	2.820	2.960	3.020

*PEDCR = Price Elasticity of Demand Controlling for Credit Rationing

5 Conclusion

In this paper I have examined the determination of the PED over the housing cycle due to variation in the number of effective substitutes. Four main influences on the number of effective substitutes have been put forward: the total number of dwellings on the market in the borrowers price range; the expected time on the market of each dwelling for sale; the heterogeneity of the dwelling stock and the search capacity constraints/efficiency of the housing market in question. I have also argued that the magnitude of PED may be an important determinant of the housing cycle, particularly if it is itself found to be cyclical. If for example, demand becomes elastic during a boom, then this may provide a self-adjustment mechanism to the cycle since successive price rises will produce proportionately lower increases in demand, than if demand remained inelastic. Put another way, it has been shown how, for a given level of excess demand, the new equilibrium price following a 'cobweb' type adjustment will be lower, the greater the elasticity of demand. If, however, there is some intrinsic constraining limit to the value that PED can rise to, then the potency of this self-adjustment mechanism will be curtailed and the boom may continue longer and to a greater intensity than where PED is free to respond the increasing number of dwellings coming on to the market.

The empirical section of the paper used time specific estimates of hedonic prices equations (a separate price equation is estimated for each quarter and each region over a twenty year period) to provide the first picture of how PED and IED vary over the economic cycle (these estimates were based on large sample regression analysis in each year – over 4,400 observations on average). It is found that the price elasticity of demand does indeed have a strong cyclical element over the period 1981 to 1995 inclusive, but never rises above 0.7 in absolute terms. We also find some evidence that credit rationing bites most severely during slumps (i.e. lenders revise down their expectations of the borrowers appropriate income multiple more rapidly than the borrowers do). An estimate of market efficiency (defined in terms of price search capacity and information efficiency) was also presented, based on the sensitivity of PED to real hedonic price movements. However, whether the estimate points to a relatively efficient or inefficient housing market in London and the South East will only become apparent when the measure is calibrated for other markets.

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