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AND THE HOUSING MARKET

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Discussion Paper 021

SELF-SELECTIVE SCREENING, LEMONS
AND THE HOUSING MARKET

Peter Chinloy*

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SELF-SELECTIVE SCREENING, LEMONS
AND THE HOUSING MARKET

Peter Chinloy

1. Introduction

The conventional approach to estimation of economic depreciation has been to fit a form to data from the age distribution of observed market trades. This is as much the case for housing as other durables but some perverse results have been obtained. Price paths for apartment buildings have been indicated as almost flat in certain age ranges, and sharply downward sloping in other age ranges.⁠¹ Rented apartment units for housing, estimated for different cities, also indicate zero depreciation and in some cases an upward slope with age.⁠²

This method can be criticized on two counts. First, market trades are liable to represent a low quality adverse selection from the underlying population. Therefore the price profile of a house vintage can decline even when no depreciation is observed. Second, suppose depreciation functions are fitted to more representative data, for example from the census of housing. If the observed price profile is uncorrected for repair

¹See Wykoff (1974).

²Gillingham (1975) estimated conventional depreciation functions for rented housing in ten U.S. cities, using census tract data covering units up to fifty years old, built between 1920-1970. Downward depreciation functions were obtained for Chicago, Los Angeles, Boston, Baltimore and San Francisco. The functions for Pittsburgh and Washington were flat for the entire period, while those for Cleveland and St. Louis were flat for extensive subperiods. The function for Detroit was increasing over a sample range indicating negative depreciation.
expenditures, any shape is possible. Repair is endogenous, and therefore the rate of depreciation is endogenous.

The objective of this research is to present an estimate of true economic depreciation for housing, and to indicate the problems inherent in the conventional models. Houses are assumed to possess initially unobservable attributes, which distinguish some as lemons. Repair expenditures may be directed toward upgrading these low quality units.

This fusion of theories of adverse selection, repair and depreciation is shown to have substantial implications. In general, market data will yield depreciation estimates biased upwards. A model which excludes repair will yield depreciation estimates biased downward or even negative, inconsistent with any definition of this phenomenon. It appears that low quality is a problem in the housing market, and that repair expenditures are directed toward upgrading these units. The saving in repair through reduced depreciation is substantially below the average maintenance rate. Houses are not of uniform quality.

2. **Price Behavior and Depreciation**

Consider transactions on new housing, where controls can be introduced for differences in observable quality such as type of plumbing. The supply of new housing is perfectly inelastic in the short run, given costs and delays in land acquisition and assembly, zoning approval, construction and sale. Some quality attributes of housing are not observable. Suppose these unobservable characteristics classify houses into two groups, good and lemons. The implications are generalizable to cases with more than two qualities.
This population of new houses therefore can be categorized

(1) \begin{align*}
\text{Good} & \quad \lambda_0 \\
\text{Lemons} & \quad 1 - \lambda_0
\end{align*}

into the two groups. All participants in purchase or sale of houses are assumed to be risk neutral.

The demand for new housing is a function of price and quality

(2) \[ D_0 = D_0(P_0, \lambda_0) \]

with \( \partial D_0 / \partial P_0 < 0 \) and \( \partial D_0 / \partial \lambda_0 > 0 \) where \( P_0 \) is the price of a new house. The demand function includes an unbiased point estimate of the average quality expected in the market. When \( \lambda_0 = 1 \) all houses constructed are good, and will sell for price \( P_G \). Uncertainty on quality is also removed when all units are lemons, in which case the market price is \( P_L \). The market price for new houses is in general

(3) \[ P_0 = \lambda_0 P_G + (1 - \lambda_0) P_L \]

where for the instant \( P_G \) and \( P_L \) are assumed to be constant over time.

The price \( P_G \) is an effective price corresponding to the quality change corrections of hedonic price indexes.\(^3\) The difference is that the adjustment \( P_G / P_0 \) is not directly observable. Under perfect information, a good house would sell for \( P_G \), the present value of its expected future services. Therefore any shift in market mix of sales which increases the proportion of lemons will reduce average prices.

---

\(^3\)In these adjustments expenditures are decomposed into price and quantity components, with the price pertaining to a constant definition bundle of attributes. See Griliches (1971).
Market equilibrium for new houses requires

\[ D_0(p_o, \lambda_0) = S_0 \]

where \( S_0 \) is the fixed supply of new housing, and

\[ P_0 = p_0(\lambda_0, S_0) \]

solves for the initial price. The situation is depicted in Figure 1, together with the no uncertainty quality specifications. Equilibrium requires that all new houses be sold.

Subsequent to purchase, information becomes available on the quality of the house. The appearance of plumbing or roof leaks, peeling plaster or defective furnaces will provide quality signals to owners. The assumption of constancy in \( P_G \) and \( P_L \) implies that only minor repairs are required on good houses, but substantial augmentation of services is required to upgrade lemons. In addition, repair costs to convert lemons to good units vary across the population, being dependent on value of time and repair proficiency.

Secondhand or resale houses aged one period have market demand

\[ D_1 = D_1(p_1, \lambda_1) \]

where \( \lambda_1 \) is an unbiased estimate of the average quality of house appearing on the resale market. Supply in the resale market can be expressed as

\[ S_1 = S_1(p_1, R_1) \]

with \( R_1 \) being the repair cost expenditure required to restore a lemon to a good unit. If the supply function (7) is fitted to individual data the personal characteristics of owners will enter \( R_1 \). Moreover, repair policy
FIGURE 1. Market for New Houses Under Different Quality Specifications
is not exogenous, but is under the control of owners, so a simultaneous equation estimation is required. The supply function has the properties \( \partial S_1 / \partial P_1 > 0, \partial S_1 / \partial R_1 > 0 \). As repair costs increase, individuals are less willing to effect repairs and will offer their houses for sale instead.

Equilibrium in the one period age group requires

\[
D_1(P_1, \lambda_1) = S_1(P_1, R_1)
\]

implying

\[
P_1 = P_1(\lambda_1, R_1)
\]

is the resale price. It is possible to compare the new and resale markets. Suppose \( D_0 = D_1 \), or people expect the demand function in price-quantity space to contain the same mixture of quality among new and resale units. This is implicitly assumed in conventional depreciation studies, for any decrease in \( \lambda \) over time arises from physical decay on average, and not an adverse selection in the market.

The supply function \( S_1 \) is more elastic and lies to the left of \( \bar{S} \). This is because the potential supply is limited by \( \bar{S} \) and a potential seller is more capable of price-responsiveness in the resale market. The market is illustrated in Figure 2. If \( D_0 = D_1 \) and \( \bar{S} - S_1 > 0 \) then resale prices will be higher than new prices. Prices are assumed discounted by any overall inflation rate. Hence used prices will appear higher than new prices and negative depreciation will be observed.

This result will obtain even if \( \lambda_0 > \lambda_1 \). The demand curve in Figure 2 \( D_\star(P_0, \lambda_\star) \) at one point solves the equation

\[
D_\star(P_0, \lambda_\star) = S_1(P_0, R_1)
\]
FIGURE 2. Two Periods of House Transactions (New and Resales)
and average quality in the resale market is lower than in the new market. This can occur if the proportion of lemons offered is increasing over time. Alternatively, Figure 2 can be interpreted as referring to a market with no quality variation, where depreciation reduces the quality index from $\lambda_0$ to $\lambda_*$ over time. If market prices are used to estimate a rate of depreciation, the rate obtained is zero. However, demanders have shifted their curve downward precisely because of a lower and unbiased quality expectation.

It is assumed in the model presented that $P_G$ and $P_L$ are constant. Suppose the demand curve solves the equation

$$D_1(P_1, \lambda_1) = S_1(P_1, R_1)$$

in the resale market. This arises with a relative preponderance of lemons being offered. A lower quality estimate $\lambda_1$ on the demand side is accompanied by a lower market price. For a given schedule of repair costs, some lemon owners will find it more advantageous to sell, where their house is homogeneous to all others offered, than to repair.

The market price is therefore $P_1$ and a depreciation rate of

$$\delta_1 = \ln P_1 - \ln P_0$$

is suggested. In turn, if statistics based on sample market data are applied to the population stock, the depreciation expense is $\delta_1 \bar{S}$, when true economic depreciation is zero. The positive estimate is obtained solely because of an adverse selection in the market. More generally, if the $\lambda$ elements represent both depreciation and adverse selection, depreciation estimates based on market data will be biased upwards.

Those who completely repair their house augment the stock of good units. At the end of this period, the stock data are
(13) \[\text{(Population)} \quad \text{Good} \quad \lambda_0 + \gamma_1(R_1)(1-\lambda_0) \]
\[\text{Lemons} \quad (1-\lambda_0)(1-\gamma_1(R_1))\]

where \(\gamma_1(R_1)\) is the fraction of the lemon stock upgraded and now facing \(P_G\). The market data are

(14) \[\text{(Market)} \quad \text{Good} \quad \lambda_1 \]
\[\text{Lemons} \quad 1-\lambda_1\]

and making the discrete time convention that sales occur at the end of the period, the bias is

(15) \[\beta_1 = \lambda_1/[(\lambda_0 + \gamma(R_1)(1-\lambda_0))]\]

from using market data. The bias has two sources, both attributable to repair costs. Lemon owners with low \(R_1\) can repair, augmenting the good stock. Those with high \(R_1\) will sell, forcing down the average quality in the market.

An additional implication is that the price \(P_1\) in the resale market is not independent of the actual repair and maintenance policy. If \(R_1 = 0\) and no owners effect repairs, \(S_1\) shifts left since either repairs are costless or none are required. In such cases, fewer owners will offer houses for sale, since any defect can be corrected costlessly, and resale prices will increase. Moreover, the apperception of improved quality will shift demand upwards, further increasing prices.

Consider the market for resales in the \(t^{th}\) age group. The supply equation is

(16) \[S_t = S_t(P_t, R_t)\]
and demand is represented by

(17) \[ D_t = D_t(P_t, \lambda_t) \]

for this market. Equilibrium requires \( D_t = S_t \), which yields

(18) \[ P_t = P_t(\lambda_t, R_t) \]

as the price for a \( t \) period old house.

The population stock of houses which are good in this period is

(19) \[ g_t = \lambda_0 + \gamma_1(R_1)(1-\lambda_0) + \gamma_2(R_2)(1-\gamma_1(R_1))(1-\lambda_0) \]
\[ + \cdots + \gamma_t(R_t)(1-\lambda_0)(1-\gamma_{t-1}(R_{t-1})) \cdots \]
\[ = \lambda_0 + (1-\lambda_0) \left[ \sum_{i=1}^{t} \gamma_i(R_i) \prod_{j=1}^{i-1} (1-\gamma_j(R_j)) \right] \]

since \( \gamma_0(R_0) = 0 \). The stock proportion represents the initial group which was good \( \lambda_0 \) in addition to the cumulative effect of the upgrading process,

\[ (1-\lambda_0) \left[ \sum_{i=1}^{t} \gamma_i(R_i) \prod_{j=0}^{i-1} (1-\gamma_j(R_j)) \right]. \]

Since \( P_G \) is constant, once lemons have been repaired, they remain in good condition except for routine maintenance. The lemon proportion is

(20) \[ n_t = (1-\lambda_0) \left[ 1 + \sum_{i=1}^{t} \gamma_i(R_i) \prod_{j=0}^{i-1} (1-\gamma_j(R_j)) \right] \]

at the same age group.

As houses age, even if \( P_L \) does not decline, more information becomes available on quality. Hence it is plausible for \( \partial R_t/\partial t > 0 \), where the cost of a given repair policy increases with age. Not all lemon owners are immediately aware of the low quality of their house, as no repair
expenditures are deemed necessary. Low quality requires observation, particularly for housing. This implies that there is a tendency for the supply curve to drift rightward, as illustrated in Figure 3.

As \( R_t \) increases over time, even at a constant expectation of average quality by prospective buyers, the price declines. As repair costs rise, owners have a tendency to offer more houses to the market and this in general will elicit a reduced demand, further decreasing prices. It is not inconceivable for this structure to continue until the price reaches zero, as postulated by Akerlof (1970) and Spence (1974), but such is unlikely to be the case for housing.

The observed evidence will suggest a decreasing sequence of resale prices by age, inflation and observable quality constant. This sequence may yield positive depreciation rates \( \delta_t = \ln P_t - \ln P_{t-1} \), but no depreciation is present.

The average quality in the market is \( \lambda_t \), and hence the quality bias is

\[
(21) \quad \beta_t = \frac{\lambda_t}{g_t}
\]

\[
= \lambda_t / \left[ \lambda_0 + (1-\lambda_0) \left[ \sum_{i=1}^{t} \gamma_i(R_i) \prod_{j=0}^{i-1} (1-\gamma_j(R_j)) \right] \right]
\]

at age \( t \). The deteriorating market mixture causes \( \lambda_t \) to fall below \( \lambda_0 \), which is augmented by repair policies. As indicated in Figure 3, as long as repair costs rise with age through quality discovery and expected quality is non-increasing on the demand side, prices will decline.

The model presented assumes that \( \lambda_t \) indicates only the degree of average quality appearing in the market. More generally \( P_G \) and \( P_L \) will decline with age and expectations on these series will enter buyers'
FIGURE 3. Multiperiod Market Model with Declining Prices
estimates of \( \lambda_t \). Therefore, when market demand functions are observed as \( D_t(p_t, \lambda_t) \) and a sequence such as that depicted in Figure 3 arises, several explanations of the phenomena are possible. First, in the adverse selection model as presented the \( \lambda_t \) represent the market mix and not the population stock. In the extreme case, if \( P_G \) and \( P_L \) are constant, houses are not depreciating, but \( \lambda_t \) can decline if lemons predominate in the resale market. Second, the \( \lambda_t \) decline may represent solely the expectation that physical depreciation of a homogeneous housing stock exceeds net maintenance. Third, the \( \lambda_t \) sequence can contain a mixture of depreciation and adverse selection elements, and a distinction between them is necessary.

3. **Depreciation and Adverse Selection**

3.1 Testing the Lemons Model

Empirically, the first problem is to determine whether lemon effects are statistically significant and affect market behavior. If there is such evidence, the potential bias in the estimation of depreciation functions must be measured.

The lemons model yields empirical predictions which differ from the conventional neoclassical model of depreciation. In the conventional model, all quality is observable, and houses can be defined in homogeneous units. Therefore, maintenance and repair ratios will exhibit no variance over the stock. Let repair expenditures be

\[ ... \]

\(^4\)Alternatively, \( \lambda_t \) can be regarded as representing only adverse selection effects, with depreciation treated by including \( P_{G,t} \) and \( P_{L,t} \) as explicit arguments of the demand function.
on a house of age \( t \). Repairs \( R_t \) are expressed as the product of an asset price of capital \( \phi \) and a quantity index of capital \( M_t(H^R) \) where \( H^R \) is a proper subset of \( H \), a list of household and house characteristics.

The selling price of a house, using the reduced form function (18) is

\[
P_t(\lambda_t, R_t) = \phi Q_t(H)
\]

where repair capital is assumed identical to the remaining capital in the stock and \( Q_t(H) \) is a quantity index at the beginning of age \( t \). The repair ratio is

\[
r_t = m_t(H)
\]

where \( r_t = R_t/P_t \) and \( m_t = M_t/Q_t \), dependent on both the supply and demand characteristics in \( H \).

The conventional model predicts that \( r_t \) will be substantially explained by the characteristics in \( H \). By contrast, the lemons model argues that most quality is unobservable to the market and that \( H \) will not explain a substantial proportion of the variation in \( r_t \). If this were not the case, a variable 'lemon quality' could be added to the list in \( H \) and the problem would disappear.

The predictions are therefore

\[
(\text{Conventional}) \quad \text{var} \left. r_t \right|_H = 0 \text{ or negligible}
\]

\[
(\text{Lemons}) \quad \text{var} \left. r_t \right|_H > 0
\]

on the repair ratios. A stronger version of the conventional model holds
that maintenance is dual to depreciation, which is geometric.\textsuperscript{5} While this hypothesis, even within the conventional literature, has been challenged, it yields a restriction on repair ratios.\textsuperscript{6} It implies that repair ratios are constant, controlling for house quality or

\begin{equation}
\left. r_t \right|_{H^K} = \text{constant}
\end{equation}

where $H^K$ is a proper subset of $H$ which excludes age and household characteristics.

There is another distinction between the conventional and lemons models. Repair expenditures are assumed to augment capital uniformly, given the homogeneous nature of the housing stock. It therefore follows that repair expenditures and selling prices should be positively correlated. In the lemons model, owners of good units do not need to perform more than perfunctory repair tasks, and expenditures will be directed toward low quality units. A signal of low quality, were this observable, is the expenditure on repair. This yields

\begin{align}
\text{(Conventional)} & \quad \rho(R_t, P_t) > 0 \\
\text{(Lemons)} & \quad \rho(R_t, P_t) \leq 0
\end{align}

where $\rho$ is the coefficient of correlation.

\textsuperscript{5}This argument is developed in Jorgenson (1973).

\textsuperscript{6}Investigation of whether repair ratios are constant have been performed by Feldstein and Foot (1971) using aggregate investment and capital stock data and Bitros (1976) using actual repair expenditures on railroad rolling stock. A problem arises in using aggregate data because capital stock series as published by the Department of Commerce assume geometric depreciation, and cannot therefore be used to test related hypotheses. The railroad study indicates repair ratios to be non-constant.
The predictions (25) and (27) can be examined with data to determine whether the effects discussed are present. The essential issue is the extent to which the quality of a house can be represented by its measurable characteristics. The tests also establish whether adverse selection affects economic variables "only at the fifth decimal place" and whether it is distinguishable from conventional models.  

3.2 Correcting for True Economic Depreciation

The second magnitude to be determined empirically is the true depreciation rate. Because of possible adverse selection, market data cannot be used to estimate such functions. If lemon effects are shown to occur, depreciation rates can only be estimated by using population data.

Two modifications must be made prior to empirical implementation of the model. First, quality cannot be expressed in binary form, particularly for housing. Rather, there is a continuum of housing quality, with houses requiring no or negligible repair being designated good, and those requiring substantial repairs classified as lemons. Second, price profiles are downward sloping over time, as opposed to being flat, although the \( P_g \) and \( P_L \) may be interpreted as annuity prices of good and lemon units. A property of lemons may be more rapid deterioration.

Solely for classification purposes, houses where \( R_t = 0 \) are designated good. This introduces the possibility that some lemons owners make no

---

7 The first charge has been levelled against search theory, and no concerted attempt has been made to prove or disprove it. See Rothschild (1973). The second has been raised by Lazear (1976) in connection with screening theory as opposed to human capital theory in the labor market.

8 This is formally analogous to the annuity value of education concept of Mincer (1974).
repair expenditures, or that good owners incurring preventive maintenance allocations are misclassified. In the housing market, the former case is unlikely if more that a fine quality distinction is to be made. In the latter case, the effect should reduce measured good-lemon differentials, acting in the opposite direction of the model predictions.

Taking logarithms of (23) and selecting on \( R_t = 0 \) yields

\[
\ln P = \ln \phi + \ln Q(H)
\]

and the observed depreciation rate is \( \frac{\partial \ln P}{\partial t} \), where age \( t \) is a characteristic of \( H \). This therefore constitutes the good unit depreciation rate for the underlying population, since the data in (28) are not market transactions. This yields

\[
d_q(H) = \left. \frac{\partial \ln Q(H)}{\partial t} \right|_{R=0}
\]

which may be dependent on house or household characteristics including age itself. Tests of separability are required to determine whether good depreciation is independent of \( H \).

The lemons group is heterogeneous, an indicator of which is repair expenditure. Selecting on \( R_t > 0 \) yields another asset price equation, together with the maintenance ratio (24). The depreciation rate on lemons is therefore the sum of observed asset price change plus the rate of maintenance. This is

\[
d_L(H) = \left. \frac{\partial \ln Q(H)}{\partial t} \right|_{R>0} + m(H)
\]

for the lemon depreciation rate, which has two components. The first is the observed decline in asset prices with age, characteristics constant.
These asset prices reflect the net effect of depreciation after maintenance expenditure. Even if it is not possible to construct factor augmentation indexes of H for repairs, the selling price will increase through a shift effect under the conventional model. The prediction is

\[
\frac{\partial H}{\partial t} \bigg|_{R>0} < \frac{\partial H}{\partial t} \bigg|_{R=0}
\]

but as in (25), the lemons model suggests equality or a reversal.

The second component of lemons depreciation is the maintenance expenditure. If (31) holds, it is possible for lemons to depreciate at a slower rate, even though \( m(H) \geq 0 \). The lemons model has as a strict provision, however

\[
d_L(H) > d_G(H)
\]

since it hypothesizes the reverse of (31) with \( m(H) \geq 0 \). If (32) is the case, the downward bias in measured depreciation rates becomes apparent from market data. That the market for used durables becomes dominated by low quality units has been strongly advocated.\(^9\) The market average of

\[
d_M(H) = \beta_t d_G(H) + (1-\beta_t)d_L(H)
\]

will therefore be polluted, since \( \beta_t \) is biased downward. In the limiting case where the generalized Gresham's Law operates\(^10\) \( \beta_t = 0 \) and if (32) also

\(^{9}\)See Akerlof (1970) and Heal (1976). The latter argues that bad units drive out good in cases where buyer and seller deal only infrequently. This will be particularly the instance in the housing market. Moreover, since sellers are often owners in the resale market, integrity and reliability cannot be established.

\(^{10}\)See Akerlof (1970).
holds, \( d_M(H) = d_L(H) \). But since \( \beta_t \) obtains in the market only, the true depreciation rate is

\[
(34) \quad d(H) = \alpha \ln Q(H)/\alpha t + m(H)
\]

for the entire sample \( R_t \geq 0 \), and the measured rate will be biased upwards.

The above permits several aspects of depreciation in housing to be analyzed. True rates of economic depreciation \( d(H) \) can be estimated. Separate rates are calculable for good and lemon units, which in turn can be combined to determine the upward bias from using market data. From (32), the central hypothesis of the lemons model that measured depreciation rates using market data are biased upward can be tested. In neither the conventional nor adverse selection model is geometric depreciation maintained. Depreciation is variable rather than parametric, with geometric forms being specific testable cases.

4. Data and Sample Selection

The data to be used are from the Survey of Housing Units (SHU) conducted by the Canadian government agencies Statistics Canada and Central Mortgage and Housing Corporation (CMHC) in 1974. The SHU is a cross-sectional survey, thereby avoiding market shifts in demand and supply present in time series data. In addition, identifying restrictions are required to distinguish inflation from depreciation in time series data.11

The sample is restricted to London, Ontario because of the

11See Hall (1971).
availability of other supportive data. The basic sample contains 3,436 dwelling units for this city, selected randomly from the entire housing stock. The sample is restricted to single family owner-occupied dwellings, and to those households responding to a question on expected selling price.

The expected price question is also asked in the U.S. Housing Census and Michigan Income Dynamics Survey. As part of its procedural verification, Statistics Canada compared expected selling prices with actual transaction prices, and no significant differences were uncovered. The selection procedures reduce the eligible sample to 1219 houses. The basic characteristics of this sample are indicated in Table 1.

A feature of the SHU data is a question on repair expenditure, explicitly distinct from additions. These expenditures are reported for 1973 and are defined as the dollar value including sales tax of any requirements for repair and maintenance. Additions, renovations and improvements are excluded in the instructions for the questionnaire guide. Included are roof repairs, shingles, painting, and repair of siding, broken windows, electrical and heating equipment. What is excluded is the imputation for time expended by owners. It is subsequently shown that any such imputation will fortify the results. It is assumed that repair output is characterized by a neoclassical technology where $M(H) = 0$ for any $h \in H = 0$. Those with zero direct repair expenditures therefore performed no repairs. In addition, personal characteristics are included in $H$, as indicated in Table 1, and these augment $M(H)$ at a given direct expenditure level.

An additional feature is an attempt to measure the exterior quality of the house, in the variable QUAL. This evaluation was performed by the

TABLE 1. Basic Characteristics of Housing Sample

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Brief Description</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPAIR</td>
<td>Expenditure for repair in 1973</td>
<td>$207</td>
<td>$513</td>
</tr>
<tr>
<td>LOGSELL</td>
<td>Logarithm, expected selling price of survey date (1974)</td>
<td>10.55</td>
<td>.37</td>
</tr>
<tr>
<td>MAINT(X100)</td>
<td>Maintenance ratio REPAIR/PRICE</td>
<td>.57</td>
<td>1.37</td>
</tr>
</tbody>
</table>

House Characteristics

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Brief Description</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUAL</td>
<td>Exterior structural quality index</td>
<td>2.93</td>
<td>.35</td>
</tr>
<tr>
<td>LIVRMS</td>
<td>Number of living rooms</td>
<td>3.33</td>
<td>.89</td>
</tr>
<tr>
<td>BEDRMS</td>
<td>Number of bedrooms</td>
<td>3.06</td>
<td>.78</td>
</tr>
<tr>
<td>WRKRMS</td>
<td>Number of work rooms (=1 if present)</td>
<td>.05</td>
<td>.22</td>
</tr>
<tr>
<td>LIVAR</td>
<td>Area of living rooms (sq.ft.)</td>
<td>572.32</td>
<td>247.02</td>
</tr>
<tr>
<td>BEDAR</td>
<td>Area of bedrooms (sq.ft.)</td>
<td>366.46</td>
<td>154.66</td>
</tr>
<tr>
<td>WRKAR</td>
<td>Area of work rooms (sq.ft.)</td>
<td>129.40</td>
<td>671.80</td>
</tr>
<tr>
<td>LANDL</td>
<td>Land use - left side of structure</td>
<td>.92</td>
<td>.28</td>
</tr>
<tr>
<td>LANDR</td>
<td>Land use - right side of structure</td>
<td>.88</td>
<td>.32</td>
</tr>
<tr>
<td>LANDOP</td>
<td>Land use - opposite structure</td>
<td>.94</td>
<td>.24</td>
</tr>
<tr>
<td>CON1</td>
<td>Constructed before 1940</td>
<td>.2806</td>
<td>.4495</td>
</tr>
<tr>
<td>CON2</td>
<td>Constructed 1941-1950</td>
<td>.1485</td>
<td>.3557</td>
</tr>
<tr>
<td>CON3</td>
<td>Constructed 1951-1960</td>
<td>.2461</td>
<td>.4309</td>
</tr>
<tr>
<td>CON4</td>
<td>Constructed 1961-1970</td>
<td>.1756</td>
<td>.3806</td>
</tr>
<tr>
<td>CON5</td>
<td>Constructed after 1971</td>
<td>.1492</td>
<td>.3562</td>
</tr>
</tbody>
</table>

Household Characteristics

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Brief Description</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINC</td>
<td>Logarithm household income in 1973</td>
<td>9.26</td>
<td>.88</td>
</tr>
<tr>
<td>LINCHD</td>
<td>Logarithm, household head income, 1973</td>
<td>8.93</td>
<td>.98</td>
</tr>
<tr>
<td>AGE</td>
<td>Age of head</td>
<td>47.68</td>
<td>15.48</td>
</tr>
<tr>
<td>SEX</td>
<td>Sex of head (male = 1, female = 0)</td>
<td>.88</td>
<td>.32</td>
</tr>
<tr>
<td>MAR</td>
<td>Marital status of head</td>
<td>.14</td>
<td>.34</td>
</tr>
<tr>
<td></td>
<td>(married = 0, other = 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSIZE</td>
<td>Household size, number of persons</td>
<td>3.55</td>
<td>1.57</td>
</tr>
<tr>
<td>CHILD</td>
<td>Number of children under 18</td>
<td>1.09</td>
<td>1.30</td>
</tr>
</tbody>
</table>

Note: Land use variables take value of unity if used for single family homes and zero otherwise.
interviewer, and details of the construction are presented in Table 2. Since QUAL is observable, it should be included as one of the explanatory variables, and can provide some signal of quality.

The notable omission from the SHU data is information on lot size and characteristics. However, in London, the market for single family lots is thin and tied sales of house and land are offered for purchase.\(^\text{13}\)

Moreover, the quality of a structure may be related to the quality of the lot. This is particularly the case with servicing and sewer mains, and implies that an arbitrary allocation rule to evaluate the value of land can lead to erroneous results.\(^\text{14}\) Therefore any depreciation rates are applicable to the entire package.

It may be the case that older houses reside on more valuable lots. This poses a problem only if the interest is in estimating depreciation for the structure separately. If lemons arise because of land characteristics such as sewers "backing-up," such a distinction is not necessarily appropriate.\(^\text{15}\) It does imply that structure-only depreciation rates can

\(^\text{13}\)See Davies (1977).

\(^\text{14}\)Such a procedure is applied to the Canadian aggregate housing stock, itself constructed using geometric depreciation and a perpetual inventory method, by Christensen, Cummings and Jorgenson (1976). It is also assumed there that land has a zero depreciation rate. For single family lots, this may not be the case if the embedded servicing deteriorates or becomes obsolete. A specific example is the reduced requirement for in-ground sewer mains over time.

\(^\text{15}\)Attempts were made to examine the argument. Mortgages are insured by CMHC under the National Housing Act, and information on an assessment of land is collected. However officials considered these data to be of uneven quality. In addition, estimates of a rent gradient for London were constructed using lot transactions data for 1974, and separately using multiple listing service transactions prices for the same year. In the former case, the absence of close to downtown data caused gradients to assume various shapes. For the latter, an interaction between age and lot size proved insignificant.
TABLE 2. Evaluation of Exterior Quality (QUAL)

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Sagging roof</td>
</tr>
<tr>
<td>02</td>
<td>Sloping walls</td>
</tr>
<tr>
<td>03</td>
<td>Poor foundations (crumbling, cracking cement, open holes)</td>
</tr>
<tr>
<td>04</td>
<td>Decaying wood (window and door sills)</td>
</tr>
<tr>
<td>05</td>
<td>Shingles missing from the roof in quantity</td>
</tr>
<tr>
<td>06</td>
<td>Sagging eaves</td>
</tr>
<tr>
<td>07</td>
<td>Broken windows</td>
</tr>
<tr>
<td>08</td>
<td>Loose bricks (including poor siding)</td>
</tr>
<tr>
<td>09</td>
<td>Poor porch footings</td>
</tr>
<tr>
<td>10</td>
<td>Poor paint                                     <strong>Note</strong>:</td>
</tr>
<tr>
<td>11</td>
<td>Poor grading (area next to structure sloping towards foundation)</td>
</tr>
<tr>
<td>12</td>
<td>None of the above</td>
</tr>
</tbody>
</table>

QUAL = 1 where one or more of 01-04 exist or three or more of 05-11
= 2 where none of 01-04 exist and two of 05-11
= 3 where none of 01-04 exist and one or less of 05-11
If none of 01-12 checked, the house was removed from the sample

be biased downward, with the improved quality of older land masking house deterioration.

Finally, a potential for adverse selection lies in scrappage and demolition of low quality units. If the recourse to owning a lemon is to eliminate it, the average quality will improve over time and depreciation profiles will tend to be flatter. However, the combined demolition and conversion rate for single family dwellings in London is estimated at .0000365.\textsuperscript{16} Since conversions do not necessarily involve low quality and some demolitions can arise through natural causes, the impact of scrappage is further reduced.

5. \textbf{Empirical Results}

The tests to determine the magnitude of lemon effects are reported in Table 3, based on the hypotheses of (25) and (27). The houses are grouped into the five periods of construction, with $N$, $\bar{P}$ and $\bar{R}$ denoting respectively the sample size, mean expected selling price and mean repairs in each group.

The simple correlation coefficient within the group $\rho(P,R)$ is reported, and is positive for four of the periods, suggesting some plausibility for the conventional model. At the same time, the lone negative coefficient occurs for new houses, where quality may be immediately less simple to observe. In no case is the correlation coefficient of substantial magnitude. As a further test of (27), the logarithm of selling price was regressed on the entire list of characteristics in Table 1 and an instrumental variable prediction $\hat{R}$. This $\hat{R}$ was obtained by a regression of $R$ on a series

\textsuperscript{16}See Davies (1977, p. 62).
TABLE 3. Preliminary Tests on Conventional and Lemons Depreciation Models

<table>
<thead>
<tr>
<th>Date of Construction</th>
<th>N</th>
<th>( \bar{P}(\text{'000}) )</th>
<th>( \bar{R} )</th>
<th>( \rho(P,R) )</th>
<th>( R^2(\text{eq.25}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre 1940</td>
<td>344</td>
<td>34.0</td>
<td>316</td>
<td>.2048</td>
<td>.0486</td>
</tr>
<tr>
<td>1941-1950</td>
<td>182</td>
<td>35.7</td>
<td>218</td>
<td>.0017</td>
<td>.0533</td>
</tr>
<tr>
<td>1951-1960</td>
<td>299</td>
<td>41.7</td>
<td>254</td>
<td>.2044</td>
<td>.0887</td>
</tr>
<tr>
<td>1961-1970</td>
<td>213</td>
<td>47.9</td>
<td>123</td>
<td>.1586</td>
<td>.1207</td>
</tr>
<tr>
<td>Post 1971</td>
<td>181</td>
<td>52.2</td>
<td>61</td>
<td>-.1673</td>
<td>.0851</td>
</tr>
</tbody>
</table>
of other variables. The coefficient of \( \hat{R} \) was .00000059 and not significant, although numerically positive.

To correspond with (25), the observed maintenance ratio was regressed on the characteristics for each group and the results reported in the last column. The proportion of variation explained by these characteristics is uniformly low and appears to decline with age. Unobservable influences appear to affect the maintenance ratio.

The results of Table 3 do not suggest rejection of any model and by themselves are inconclusive. However, the absence of any correlation between repair expenditures and selling prices for the entire sample, the negative correlation for young houses and an inability to explain the repair ratios by measured variables together suggest that the conventional model may be incomplete.

In Table 4, results for the selling or asset price equation are presented. In the first column, the sample is restricted to units for which \( R = 0 \). In the second column \( R > 0 \), and the third column reports results for the entire sample.

The main variables of interest are QUAL and CON1-CON5. Among the other variables, it is noted that none of the household characteristics affect selling prices. The behavior of QUAL in the equations is substantial. A house with no repairs and a quality designation of three, the highest permitted, faces a 22.5% price reduction. Yet among houses reporting repairs, a similar designation increases prices by 35.5%. Moreover, QUAL is the only variable which changes sign significantly across equations and has no impact in the aggregate sample. The conclusion is suggested that repair expenditures are preventive, and do not necessarily indicate low quality. On the contrary, they suggest high quality is present.
### TABLE 4. Estimates of Asset Price Equations
(standard errors in parentheses)

<table>
<thead>
<tr>
<th></th>
<th>No Repair Subsample R = 0</th>
<th>Repair Subsample R &gt; 0</th>
<th>Unrestricted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>9.8564 (.2774)</td>
<td>9.8817 (.3348)</td>
<td>10.0709 (.1274)</td>
</tr>
<tr>
<td>QUAL</td>
<td>-.0749 (.0263)</td>
<td>.1184 (.0397)</td>
<td>.0044 (.0216)</td>
</tr>
<tr>
<td>LIVRMS</td>
<td>.0799 (.0158)</td>
<td>.0802 (.0196)</td>
<td>.0791 (.0124)</td>
</tr>
<tr>
<td>BEDRMS</td>
<td>-.0358 (.0213)</td>
<td>.0611 (.0222)</td>
<td>.0167 (.0153)</td>
</tr>
<tr>
<td>WRKRM</td>
<td>.0388 (.0840)</td>
<td>.1110 (.1206)</td>
<td>.0432 (.0700)</td>
</tr>
<tr>
<td>LIVAR</td>
<td>.0001 (.0001)</td>
<td>.0003 (.0001)</td>
<td>.0002 (.0001)</td>
</tr>
<tr>
<td>BEDAR</td>
<td>.0011 (.0001)</td>
<td>.0005 (.0001)</td>
<td>.0008 (.0001)</td>
</tr>
<tr>
<td>WKRAR</td>
<td>-.0002 (.0006)</td>
<td>.0010 (.0007)</td>
<td>.0005 (.0005)</td>
</tr>
<tr>
<td>LANDL</td>
<td>-.0436 (.0363)</td>
<td>-.0379 (.0407)</td>
<td>-.0418 (.0274)</td>
</tr>
<tr>
<td>LANDR</td>
<td>-.0689 (.0292)</td>
<td>-.0010 (.0385)</td>
<td>-.0458 (.0236)</td>
</tr>
<tr>
<td>LANDOP</td>
<td>.0958 (.0397)</td>
<td>-.1244 (.0464)</td>
<td>.0031 (.0305)</td>
</tr>
<tr>
<td>CON1</td>
<td>-.4066 (.0300)</td>
<td>-.2718 (.0791)</td>
<td>-.3931 (.0263)</td>
</tr>
<tr>
<td>CON2</td>
<td>-.2809 (.0347)</td>
<td>-.1902 (.0807)</td>
<td>-.2818 (.0292)</td>
</tr>
<tr>
<td>CON3</td>
<td>-.1603 (.0297)</td>
<td>-.0502 (.0780)</td>
<td>-.1611 (.0257)</td>
</tr>
<tr>
<td>CON4</td>
<td>-.0928 (.0295)</td>
<td>.0123 (.0790)</td>
<td>-.0898 (.0261)</td>
</tr>
<tr>
<td>CON5</td>
<td>0^a</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| **Household Characteristics** |                            |                        |              |
| LINC                  | .0029 (.0215)              | .0055 (.0252)          | .0050 (.0164) |
| LINCCHD               | .0061 (.0186)              | .0135 (.0186)          | .0083 (.0133) |
| AGE                   | .0005 (.0007)              | -.0100 (.0009)         | b            |
| SEX                   | -.0027 (.0394)             | -.0548 (.0485)         | -.0174 (.0300) |
| MAR                   | -.0286 (.0349)             | -.0556 (.0492)         | -.0387 (.0133) |
| HSIZE                 | -.0110 (.0130)             | -.0268 (.0167)         | -.0157 (.0105) |
| CHILD                 | .0093 (.0150)              | -.0269 (.0202)         | -.0059 (.0122) |
| R^2                   | .5764                      | .5225                  | .5303        |
| DF                    | 711                        | 462                    | 1197         |
| MSSR                  | .0598                      | .06                    | .0655        |

^a Normalized and set equal to zero.
This conclusion is profiled by the sequence of coefficients on CON1-CON4. These are not depreciation rates in themselves, but rather points on a price-age profile. It is precisely such a series but estimated with market data, which is interpreted as a depreciation function in conventional theory.

The clear observation which arises from the CON1-CON4 sequence is that depreciation is lower on houses where repair has been performed. However, interpreting these coefficients as a depreciation profile, as in the conventional model, is inappropriate. The reason is that no account of repair is taken. Repair expenditures are endogenous, and the slower depreciation rate on R > 0 houses may arise because of repair expenditure.

While the R = 0 profile is steeper than the R > 0, this alone is not sufficient to reject the lemons model. Performing a test for pairwise equality of CON1-CON4 across the equations led to rejection. The reason why the lemons model remains a candidate is that the complete depreciation rate for R > 0 is the sum of the observed change in asset prices and repair rates. This requires estimation of the repair equation.

Suppose owners with R > 0 effect substantial repairs. Then even if this causes the observed depreciation profile to be flatter, calculated returns on these investments in preventing deterioration would be low or negative if underlying quality were assumed identical. Such investments could only be rational if an owner had commenced with a low quality house, upholding the lemons model.

The repair equation results are reported in Table 5. To conform with the model, this is an estimation of (24). The dependent variable is r, the repair ratio, estimated separately for R > 0 and the entire sample. For those who repair, the only significant variables at the 5% level are
TABLE 5. Estimates of Maintenance Ratio Equation  
(standard errors in parentheses)

<table>
<thead>
<tr>
<th></th>
<th>R &gt; 0</th>
<th>Complete Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-.0146 (.0240)</td>
<td>-.0082 (.0067)</td>
</tr>
<tr>
<td>QUAL</td>
<td>.0029 (.0028)</td>
<td>.0019 (.0011)</td>
</tr>
<tr>
<td>LIVRMS</td>
<td>-.0019 (.0014)</td>
<td>-.0008 (.0006)</td>
</tr>
<tr>
<td>BEDRMS</td>
<td>-.0023 (.0016)</td>
<td>-.0022 (.0008)</td>
</tr>
<tr>
<td>WRKRMS</td>
<td>.0004 (.0086)</td>
<td>-.0007 (.0037)</td>
</tr>
<tr>
<td>LIVAR</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>BEDAR</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>WRKAR</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>LANDL</td>
<td>.0020 (.0029)</td>
<td>-.0006 (.0014)</td>
</tr>
<tr>
<td>LANDR</td>
<td>-.0016 (.0028)</td>
<td>.0001 (.0012)</td>
</tr>
<tr>
<td>LANDOP</td>
<td>.0001 (.0033)</td>
<td>-.0002 (.0016)</td>
</tr>
<tr>
<td>CON1</td>
<td>.0171 (.0057)</td>
<td>.0098 (.0014)</td>
</tr>
<tr>
<td>CON2</td>
<td>.0100 (.0058)</td>
<td>.0062 (.0015)</td>
</tr>
<tr>
<td>CON3</td>
<td>.0090 (.0056)</td>
<td>.0060 (.0013)</td>
</tr>
<tr>
<td>CON4</td>
<td>.0011 (.0056)</td>
<td>.0022 (.0014)</td>
</tr>
<tr>
<td>CON5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| **Household Characteristics** |                |                 |
| LINC                     | .0029 (.0018)  | .0022 (.0009)   |
| LINCHD                   | -.0016 (.0013) | -.0012 (.0007)  |
| AGE                      | a              | a               |
| SEX                      | .0015 (.0033)  | -.0014 (.0016)  |
| MAR                      | a              | a               |
| HSIZE                    | a              | a               |
| CHILD                    | a              | a               |
| R²                       | .1007          | .0747           |
| DF                       | 462            | 1197            |
| MSSR                     | .00033         | .00018          |

*Numerical point estimate less than .00001 and not significantly different from zero at the .01 level.*
those associated with CON. For the entire sample, BEDRMS and LINC are also significant. Larger houses, those with more bedrooms, require lower repair ratios. Higher income households will increase their repair rates, supporting the conclusion obtained elsewhere that maintenance depends on funds available.\footnote{The basic hypothesis is advanced in Feldstein and Foot (1971) justifying the inclusion of retained earnings as an explanatory variable of maintenance rates for producer durables.}

It remains to calculate true depreciation rates for housing. The variable CON5 covers houses built 1971-1973. For the depreciation calculation, a new house will be considered as one built in 1972. The lower bound on the pre-1940 group is set at 1926. Taking the midpoints of the year groups, ages can be associated with groups as follows:

\[
\begin{align*}
\text{CON5} & \quad 0 \\
\text{CON4} & \quad 7 \\
\text{CON3} & \quad 17 \\
\text{CON2} & \quad 27 \\
\text{CON1} & \quad 39 \\
\end{align*}
\]

and the depreciation rates are obtained by dividing the CON coefficients of Table 4 by the corresponding age in (35).

Total depreciation is defined as the sum of the rate as calculated from Table 4 plus the repair rate, as in (29) and (30). Without the repair adjustment, depreciation rates are understated. The full calculation is reported in Table 6.

In the first column are the observed depreciation rates, net of repair. Those for which \( R > 0 \) appear to depreciate more slowly, for example .69% for a house-with-lot built before 1940 as opposed to 1.04% if \( R = 0 \)
TABLE 6. Estimated Depreciation Rates on Housing

<table>
<thead>
<tr>
<th></th>
<th>Asset Price Change</th>
<th>Repair</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair &gt; 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre 1940</td>
<td>-.0069</td>
<td>-.0171</td>
<td>-.0240</td>
</tr>
<tr>
<td>1941-1950</td>
<td>-.0070</td>
<td>-.0100</td>
<td>-.0170</td>
</tr>
<tr>
<td>1951-1960</td>
<td>-.0029</td>
<td>-.0900</td>
<td>-.0119</td>
</tr>
<tr>
<td>1961-1970</td>
<td>.0018</td>
<td>-.0011</td>
<td>.0007</td>
</tr>
<tr>
<td>Repair = 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre 1940</td>
<td>-.0104</td>
<td>0</td>
<td>-.0104</td>
</tr>
<tr>
<td>1941-1950</td>
<td>-.0104</td>
<td>0</td>
<td>-.0104</td>
</tr>
<tr>
<td>1951-1960</td>
<td>-.0094</td>
<td>0</td>
<td>-.0094</td>
</tr>
<tr>
<td>1961-1970</td>
<td>.0132</td>
<td>0</td>
<td>.0132</td>
</tr>
<tr>
<td>Complete Sample</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre 1940</td>
<td>-.0101</td>
<td>-.0098</td>
<td>-.0199</td>
</tr>
<tr>
<td>1941-1950</td>
<td>-.0104</td>
<td>-.0062</td>
<td>-.0166</td>
</tr>
<tr>
<td>1951-1960</td>
<td>-.0095</td>
<td>-.0060</td>
<td>-.0155</td>
</tr>
<tr>
<td>1961-1970</td>
<td>.0128</td>
<td>-.0022</td>
<td>.0150</td>
</tr>
</tbody>
</table>
However, these owners spent 1.71% on repair, and this is a conservative estimate since no indirect costs are included. Thus an \( R > 0 \) house depreciated at 2.40% if at least 32 years old in 1972, and this is a lower bound. Since even this minimum estimate is more than double the rate for \( R = 0 \), the implication is that not all repair is preventive, and that part must be attributable to lower quality.

Comparing the total rates for \( R = 0 \) and \( R > 0 \) throughout, it is clear that the latter appears to depend on age. Young houses repaired can be restored such that no depreciation on a net basis is observed. This provides a justification for not using asset price data alone to measure depreciation. In the results obtained, CON4 is numerically positive and depreciation negative, for \( R > 0 \). It is not implausible for negative depreciation to arise from data with extensive repairs.

In the conventional model, total depreciation rates should be identical, since underlying quality is homogeneous, but this is not the case. Rather, two distinct depreciation profiles emerge, one being relatively constant in slope, and the other becoming more steep with age. The saved depreciation on an \( R > 0 \) house is 1.04% - .69% or .35% per year, but this requires a minimum 1.71% per year of selling price expenditure, for houses built before 1940. Such investment decisions are irrational in a homogeneous quality model. Similarly, a saving on the 1941-1950 group of .34% requires a 1% expenditure, and the figures for 1951-1960 are .65% and .9%. A "profit" on repair expenditures can only be made if exceeded by saved depreciation annually. Moreover, the repairs data are understated, biasing conclusions against the lemons model. The results suggest that there may be problems in aggregating heterogeneous unknown qualities for capital assets.

Finally, depreciation rates are reported for the entire sample.
Since this is a representative drawing for the whole population, the results are more reliable than those obtained from market data. Asset price changes alone understate depreciation substantially, by amounts ranging from 16% to 50%. While no asset price change rates are positive, this possibility remains, leading to implausible negative depreciation.

6. Summary and Conclusions

The main conclusions are:

a. Market data are liable to contain an adverse selection of low quality houses. If low quality units are those with large repair expenses, estimates will be biased upward by a minimum of 20% in the limit, for houses built before 1940.\textsuperscript{18}

b. Depreciation estimates from asset price equations, whether population or market, are biased downward and could be negative. The exclusion of repair causes a minimum bias of 16%.

c. Low quality houses depreciate more rapidly than high quality houses, at about twice the rate after twenty years of age.

d. The lemons model appears to explain repair behavior on older houses. If quality is homogeneous, irrational repair behavior is observed, where net returns are negative.

e. Repair expenditure on younger houses appears to be preventive. Houses where $R > 0$ do not depreciate under the conventional asset price model over the first ten years.

\textsuperscript{18} If only $R > 0$ houses are sold in the market, depreciating at 2.40%, the population yields 1.99%. The minimum designation arises because no indirect repairs are included.
f. Repair ratios are not independent of house characteristics such as size or household characteristics such as income.
g. Houses, inclusive of land, appear to depreciate between 1½% and 2% in a minimum range.

The test of the lemons model is not decisive. This is not surprising given the stark manner in which competing models have been presented and the inability of any data to permit fine distinctions. Nevertheless, this research provides an attack on conventional estimation of depreciation functions based both on market transactions and population asset data.

A large component of product quality is unobservable. Low coefficients of determination are shared by many hedonic price studies. However, from repair data may arise estimates of product quality, by comparing saved depreciation with repair expenditures.
REFERENCES


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002 M.W. Frankena, "Alternative Models of Rent Control" (September 1975).


004 A.J. Robson, "The Effect of Urban Structure on Ambient Pollution" (October 1975).


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