Interest and Non-Interest Terms in the Process of Mortgage Market Clearing

F.X. BROWNE*
Central Bank of Ireland, Dublin

Abstract: The paper is devoted to a test of the hypothesis of mortgage market disequilibrium in Ireland. The mortgage rate is found to be very sluggish upwards when excess demand prevails, lending support to the mortgage rationing theory. In an incipient excess supply regime the mortgage rate is lowered to the market-clearing level instantaneously. We also obtain evidence that the down-payment ratio is used by building societies as a sorting device. The role of this non-price term creates econometric difficulties in testing for disequilibrium. These difficulties are dealt with in a novel way.

I INTRODUCTION

A much debated topic in the economic literature relating to the housing and mortgage markets concerns the precise nature of the interlinkages between these two markets. The essence of a long-standing conventional wisdom is that mortgage rates, by themselves, do not fully reflect the availability of mortgage credit. The mortgage rate is sluggish to move in response to perturbations in supply and demand and therefore rationing and, perhaps occasionally, excess supply may exist and impinge directly on the housing market. However, despite the ubiquity of this belief there are few rigorous econometric tests of the disequilibrium mortgage market hypothesis. It would appear that the conventional wisdom has come to be accepted as virtually self-evident due merely to its repeated affirmation.

The amplitude of the trade cycle in the residential construction sector is much greater than that for the economy as a whole. Indeed, it could be

argued that the trade cycle in homebuilding is probably one of the major contributors to the overall trade cycle. This is a world-wide phenomenon and not exclusive to Ireland. It has prompted policy-makers to search for counter-cyclical stabilisation policies. In the US, for example, the academic diagnosis of the problem continues to be fairly well represented by the following quote from Friend writing in 1969: "The greater impact of monetary stringency on housing than on the rest of the economy apparently is due to a capital rationing effect, resulting from deficiencies in current institutional arrange-ments for providing mortgage credit . . ." (1969, p. 8).

An indisputable fact in the Irish case is that the mortgage rate of interest is sluggish. Over the time span of the present study, 1968 to 1983 inclusive, the mortgage rate changed only 26 times in a total of 64 quarterly observa-tions. The rate remained unchanged for almost four years from 1969 Q2 to 1973 Q1. Structural and cost factors undoubtedly play a role in explaining this sluggishness. Another contributory factor is the fact that the mortgage rate is a very politically sensitive variable. Of course, the mortgage market is always cleared *ex post* in the sense that there is a unique quantity of mortgages traded. Since the mortgage rate does not vary sufficiently to ration potential customers within the quarterly observation unit of the study, non-price rationing must be used to allocate the available flow supply of mortgages. It is hypothesised that the dominant non-price variable working to this effect is the downpayment ratio. Non-price rationing creates special econometric difficulties in estimating the extent of price rationing. We deal with these below.

Measures of proxies of mortgage availability used in empirical models of the housing market tend to be somewhat *ad hoc* and to lack rigorous justifi-cation. A related drawback of these proxies is their failure to distinguish between temporary and permanent effects of mortgage market spillovers on the housing market. Does "availability", for example, have an enduring effect on housing demand and thus on house prices or does the effect only endure for the amount of time required for the mortgage market to clear?

Yet another related deficiency of conventionally-used proxy measures, whether it be changes in the stock of saving accounts available to Saving and Loan Associations (see, for example, Jaffee and Rosen (1979)) or changes in the stock of mortgages (see, for example, Hendry (1984)), is their lack of symmetry. These proxy measures presume that the mortgage market is characterised by perpetual excess demand. If the market is in equilibrium or in excess supply, then these proxy measures have no constraining effect on housing expenditure and hence simply introduce unnecessary noise into the regression analysis.

Available evidence would suggest that monetary policy in Ireland has no enduring effect on those areas of activity which are financed by bank credit. This is because money and credit are internationally tradable assets and hence

an artificial shortage (surplus) of these created by domestic monetary policy
in the interest of pursuing some domestic macroeconomic objective will be
negated by the international movement of liquid claims (see Browne, 1986).
The one area of economic endeavour which may have to be excepted from
this conclusion relates to the mortgage and housing markets. Mortgages are
generally not tradable internationally. Hence mortgage market disequilibrium
cannot be offset by a supply of close substitutes from abroad. Therefore one
of the major channels of transmission of monetary disturbances, whether
of domestic or foreign origin, is via mortgage market disequilibrium to the
housing market. The fact that the housing market is subject to such huge
cyclical variation in activity may be due in no small way to the fact that it is
a hostage to those monetary shocks. The main purpose of the present exercise
is, therefore, to test for price clearing in the mortgage market. Recent progress
in the theory of market disequilibrium and in the econometrics of disequi-
librium estimation have now rendered this task feasible.

The structure of the paper is as follows. In Section II we present our
approach to estimation of markets in dynamic disequilibrium. This stems
largely from the work of Bowden (1978). Section III contains our fleshed-out
specifications of the mortgage supply and demand schedules. The fact that
mortgage demand is predominantly a derived demand from the demand for
private sector housing is fully acknowledged by the inclusion of the arguments
affecting housing demand in the mortgage demand schedule. Section IV is
devoted to a presentation of our results and also deals with the phenomenon
of non-price rationing and how this affects our estimation of price rationing.
This is followed by an evaluation of our results and comments on the speed
of adjustment of the mortgage rate to its market-clearing level and also on our
supply and demand elasticity estimates. Section V contains some conclusions.

II DISEQUILIBRIUM ECONOMETRIC MODEL

A standard Fair-Jaffee (1972) characterisation of the non-market-clearing
model of the mortgage market runs as follows:

$$M_t^D = X_t^1 \alpha_1 + \alpha_2 r_{mt} + \epsilon_{1t}, \tag{1}$$

$$M_t^S = Z_t^1 \beta_1 + \beta_2 r_{mt} + \epsilon_{2t}, \tag{2}$$

$$M_t = \min(M_t^D, M_t^S), \tag{3}$$

$$\Delta r_{mt} = \lambda(M_t^D - M_t^S), \lambda^1 > 0, \tag{4}$$

X and Z are vectors of exogenous variables affecting demand and supply

respectively, r_m is the mortgage rate of interest and ϵ_1 and ϵ_2 are stochastic error terms which are individually normally distributed and serially independent. They are also independent of each other. Equation (3) is the short-side rule which says that the quantity transacted is the minimum of supply and demand. The model is completed by Equation (4) which provides a regime indicator with an increase (decrease) in price indicating excess demand (excess supply).

In Bowden's (1978) formulation he replaces Equation (4) with the following specification:

$$r_{mt} = \mu r_{mt-1} + (1 - \mu) r_{mt}^*, \tag{5}$$

i.e., the current actual observed interest rate (r_{mt}) is a weighted average of last period's rate (r_{mt-1}) and the current market-clearing rate (r_{mt}^*). A deficiency of the formulation in (4) is that there is no well-defined test for market clearing which occurs when $\lambda = \infty$. In other words, the market-clearing hypothesis is non-nested. A test of the market-clearing condition within the Bowden formulation is straightforward (i.e., a test of $\mu = 0$). $\mu = 1$ implies infinitely slow clearing.

Charemza (1979) and Ito and Ueda (1981) have improved upon the Bowden formulation by distinguishing between upward and downward price flexibility as follows[1] :

$$r_{mt} = \mu_1 r_{mt-1} + (1 - \mu_1) r_{mt}^*, \text{ if } r_{mt} > r_{mt-1}, \tag{6a}$$

$$r_{mt} = \mu_2 r_{mt-1} + (1 - \mu_2) r_{mt}^*, \text{ if } r_{mt} < r_{mt-1}, \tag{6b}$$

This is the procedure we employ here to test for market disequilibrium. Thus our model consists of Equations (1), (2), (3), (6a) and (6b). Invoking the short-side rule (Equation (3)), we can integrate Equations (6a) and (6b) into the structural equations for demand and supply (Equations (1) and (2)) to yield the following two equations (see Ito and Ueda, 1981, p. 695):

$$M_t = X_t^1 \alpha_1 + \alpha_2 r_{mt} + \alpha_3 \Delta r_{mt}^+ + \epsilon_{1t}, \tag{7}$$

$$M_t = Z_t^1 \beta_1 + \beta_2 r_{mt} + \beta_3 \Delta r_{mt}^- + \epsilon_{2t}, \tag{8}$$

---

1. A more general formulation of Equations (6a) and (6b), as well as Equations (5) and (4), would be to set these equations in a stochastic setting by adding error terms. Furthermore, a still more general model could be had by allowing for inter-temporal spillovers from past disequilibria in the market.

where the regime switch variables (Δr_{mt}^{+} and Δr_{mt}^{-}) are defined as follows:

$$\Delta r_{mt}^{+} = \begin{cases} r_{mt} - r_{mt-1} \, , & \text{if } r_{mt} > r_{mt-1} \\ \text{zero} & , \text{ otherwise} \end{cases}$$

$$\Delta r_{mt}^{-} = \begin{cases} r_{mt} - r_{mt-1} \, , & \text{if } r_{mt} < r_{mt-1} \\ \text{zero} & , \text{ otherwise} \end{cases}$$

and where:

$$\mu_1 = \frac{-\alpha_3}{(\beta_2 - \alpha_2 - \alpha_3)} \, , \qquad \mu_2 = \frac{\beta_3}{(\beta_2 - \alpha_2 + \beta_3)} , \qquad (9)$$

Estimates of upward and downward adjustment speeds ($\hat{\mu}_1$ and $\hat{\mu}_2$) can be derived by substituting for the estimated values of the parameters in the Equations in (9) and estimates of their respective standard errors can also be obtained by using the formulae given in Ito and Ueda (1981, p. 696). It should be noted that Equations (7) and (8) relate to the entire sample period and not just to periods of excess demand and supply, respectively.

Equations (1) and (2) above refer to the long-run optimal amounts demanded and supplied. These can clearly differ from the short-run optimal amounts when costs are incurred in adjusting asset *quantities*. Browne (1987) has argued that a defect of the above disequilibrium estimation model is that it makes no provision for sluggish *quantity* adjustment. This omission can result in biased estimates of excess demand and supply and, in some cases, can lead to the mistaken identification of an excess demand regime as one of excess supply and vice versa. The probability of incurring these biases can be greatly reduced by allowing the model to accommodate sluggish quantity adjustment. We do so here by postulating independent generalised stock adjustment mechanisms governing both the demand and supply of mortgages. (For an application of this approach with Irish data see Browne and Honohan, 1988.) A detailed account of this approach is postponed to the following section.

III DETAILS OF MODEL SPECIFICATION

The model's structural equations are given in Equations (10) to (15) in Table 1. Equation (10) is long run or desired stock supply of building societies' mortgages. It is an increasing function ($a_1 > 0$) of the difference between own yield (r_m) and the opportunity cost yield of mortgages. The latter (r_{IB}) is assumed to the three months interbank rate of interest on the Dublin

money market. The term V(Ph) is a measure[2] of the variability of house prices. For a given size of mortgage the higher is V(Ph) the greater is the probability that the market value of the average house will fall below that of the average mortgage and hence the riskier becomes the building societies' investment. For risk-averse building societies, $a_2 < 0$. Mortgage supply is also an increasing function ($a_3 > 0$) of repayments on existing mortgages (REP). The data for REP are calculated as the difference between gross mortgage advances and the change in the mortgage stock in the current period. Total resources available to building societies is denoted by SAR. It is the sum of share and deposit accounts. Finally, Ph is an index of new house prices.

Table 1: *Model Structure*

$$(M/Ph)_t^{S*} = a_0 (SAR/Ph)_t + a_1 (r_m - r_{IB})_t + a_2 V(Ph)_t$$
$$+ a_3 (REP/Ph)_t + u_{1t} \tag{10}$$

$$(MA/Ph)_t = \delta_1 [(M/Ph)_t^{S*} - (M/Ph)_{t-1}] + \delta_2 (LR - \overline{LR})_{t-1}$$
$$+ \delta_3 DR_t + u_{2t} \tag{11}$$

$$(M/Ph)_t^{D*} = b_0 + b_1 H_t^D + b_2 (r_m - r_o)_t + b_3 (r_m - r_L)_t + u_{3t} \tag{12}$$

$$(MA/Ph)_t = \phi_1 [(M/Ph)_t^{D*} - (M/Ph)_{t-1}] + \phi_2 SAV_t + \phi_3 DR_t$$
$$+ \sum_{k=4}^{n} \phi_k [(A/P)_{kt}^* - (A/P)_{kt-1}] + u_{4t} \tag{13}$$

$$H_t^D = c_0 + c_1 YP_t + c_2 (\overline{P} - \overline{Q})_t + c_3 (\sigma_{\overline{P}} - \sigma_{\overline{Q}})_t$$
$$+ c_4 (ytilt)_t + c_5 (LAC)_t + u_{5t} \tag{14}$$

$$\Delta H_t = \theta [H_t^D - H_{t-1}] + u_{6t} \tag{15}$$

2.
$$V(Ph)_t = \left[\frac{1}{5} \sum_{i=0}^{4} (Ph_{t-i} - \overline{Ph}_{t-i})^2 \right]^{1/2}$$

where

$$\overline{Ph}_{t-i} = \frac{1}{5} \sum_{i=0}^{4} Ph_{t-i}.$$

The flow supply of mortgage advances in constant price terms is given in Equation (11). It is assumed to depend upon the following variables: the difference between the building societies' desired stock supply of real-valued mortgages $(M/Ph)^{S*}_t$ and the stock of those outstanding in the previous period $(M/Ph)_{t-1}$; the deviation of building societies' liquidity ratio (LR) from its target value[3] $(\overline{LR})$ in the previous period and, finally, the downpayment ratio[4] (DR). The role of the downpayment ratio requires special attention and we postpone detailed comment on this until later. We expect $\delta_3 > 0$. Note that, instead of using the generalised stock adjustment mechanism to describe building society portfolio adjustment, we employ a partial stock adjustment mechanism which is supplemented by a servomechanistic relationship entailing the building societies retaining a constant liquidity ratio in the long run (i.e., $\delta_2 < 0$) as suggested by Anderson and Hendry (1984).

Equation (12) is the long-run equilibrium demand for real-valued mortgages. The demand for mortgages is a derived demand from the demand for houses (H^D). Neglecting, for the moment, the fact that the latter is not directly observable, we note the ostensible fact that housing and mortgage demand are, of course, not the same thing. There are a few reasons for this. First, mortgage purchase involves a hierarchy of decisions; the decision to purchase a house, the capital gearing decision (i.e., the proportion of mortgage debt to owned resources invested) and the decision with respect to source institution from which to finance the mortgage. The second of these will be affected by the expected cost of mortgage finance relative to the expected opportunity cost of equity capital $(r_m - r_o)$. The third choice is in the nature of a Hobson's choice, given, at least until relatively recently, the building societies' domination of the mortgage market for private-sector housing in Ireland. Secondly, part of the increased demand for mortgages may emanate from an increased demand for consumer durables. Owner-occupiers with low loan-to-value ratios may be motivated to increase their capital gearing by taking out a second mortgage on the house or by increasing the existing mortgage and to proceed to use the funds for asset purchase in general and consumer durables in particular. The attractions of using mortgage credit in this way rather than commercial bank credit are twofold. First, because of the political sensitivity of the mortgage rate of interest, it is generally held at a level lower than the commercial bank rate and, secondly, mortgage loans

---

3. Building societies' LR is the sum of their holdings of Government securities and bank deposits less bank borrowings as a proportion of the outstanding stock of mortgages. The target level of this $(\overline{LR})$ is assumed to be a simple five period moving average, i.e., $\overline{LR} = (1/5) \sum\limits_{i=0}^{4} LR_{t-i}$.

4. DR is defined as one minus the average loan to value ratio. The average loan is gross advances divided by the number of loans. "Value" is simply average house price.

are typically available for a maturity of twenty years while personal sector commercial bank loans for durable goods purchase, by way of contrast, are rarely available for durations greater than two or three years. This suggests that the variable $(r_m - r_L)$, where r_L is the commercial bank loan rate of interest for the personal sector, risk category A, may be an important determinant[5] of $(M/Ph)^{D*}$. Given the generally prolonged nature of the mortgage commitment process, lagged values of all the arguments in (12) are likely to be important.

The adjustment of the level of real mortgage indebtedness via mortgage advances[6] to the level desired by the public is assumed to be governed by a generalised stock adjustment mechanism. The speed with which mortgage indebtedness is adjusted to its desired level will depend not only on the difference between actual mortgage indebtedness and the desired level but also, for a given level of net worth, on the difference between the actual and desired holdings of all assets in the agent's portfolio. In other words, the mortgage demand function should be regarded as having been extracted from a set of interdependent asset demand functions and, although we are not directly interested in estimating this set as such, the specification of the mortgage demand function is influenced by the fact that it has been properly extracted from such a larger system. The upshot of superimposing this generalised stock adjustment mechanism in Equation (13) on Equation (12) is to include one-period lagged values of the own and all other assets and liabilities in the portfolio whose adjustment competes with or complements the adjustment of the own asset or liability. A more detailed account of the behaviour implied by these mechanisms is obtainable in Brainard and Tobin (1968), Smith (1975) and Friedman (1977). Thus A is a vector of assets and liabilities other than mortgages in the public's portfolio. It is assumed to consist of the following four items: total current and deposit accounts placed

5. It has been noted by Davis and Saville (1982) for the UK that: "Concern about the possibility of direct withdrawal of equity from housing by borrowers obtaining more finance than required for house purchase, and its possible implications for credit and monetary aggregates, prompted a request to mortgage lenders by the Bank of England and the Treasury in January 1982 to limit this possibility" (p. 396).

6. Data referring to the value of mortgage *approvals* by building societies (taken from the Quarterly Bulletin on Housing Statistics issued by the Department of the Environment) are almost invariably larger than the data referring to the value of mortgages actually *advanced* (taken from the same source) either in the same quarter or in the subsequent few quarters. Indeed the sum of mortgage advances over the time period of investigation (1968 to 1984) amounts to only 87 per cent of mortgages approved over the same period. Thus, for one reason or another, 13 per cent of the value of mortgage approvals are never translated into advances. It would, therefore, be misleading to use data on mortgage approvals as representing the portfolio decisions of either lenders or borrowers. By default, this implies the rather strong assumption that neither the size nor maturity structure of the stock of outstanding mortgage approvals in any way constrains current gross mortgage advances.

with the commercial banks, total small savings, the value of Government stock held by the non-bank public and total loans issued by the commercial banks. In Equation (13) we also distinguish between reallocating the existing portfolio (relatively expensive) and allocating additions (i.e., new savings, SAV) to the portfolio (a less costly procedure since asset sales are not involved). We expect $\phi_2 > 0$. The speed with which mortgage indebtedness is adjusted to its desired level via advances also depends on the downpayment ratio (DR) with an increase in DR required by the mortgage lender discouraging demand (i.e., $\phi_3 < 0$).

Equation (14) is our specification of the long-run equilibrium demand for private sector housing and Equation (15) is the standard partial stock adjustment mechanism according to which the actual stock is adjusted to this long-run equilibrium. Permanent income is denoted by YP. This is assumed to be generated by a geometrically distributed lag on current and past actual real income.[7] The real *ex post* net user cost of housing capital is P and Q is an index of the cost of the alternative mode of tenure, namely that of rented accommodation. The calculation of P is quite complex and is relegated to Appendix A of the paper. The term Q is the rental component index of the CPI for renting of private sector and local authority housing.

Two salient features of the calculated time series for P emerge immediately. First, the values calculated for the 1970s and early 1980s are predominantly and substantially negative and, secondly, they exhibit great volatility. Now, the house purchase decision is probably the most important single financial decision undertaken during the average individual's lifetime. Given the volatility of *ex post* P_t, a potential house purchaser will clearly not base his decision on the current P_t value but rather on the average value he expects to prevail over the next several years. Furthermore, given the substantial transactions costs accompanying house purchase, an actual purchase will probably commit the purchaser for a long-time horizon and hence uncertainty about the future evolution of the holding cost of home-ownership ($\sigma_{\overline{P}}$) will discourage purchase by risk-averse individuals. Ignoring measurable uncertainty, i.e., risk, can thus lead to biased results in empirical work. Clearly, the expected real holding cost of the dominant alternative mode of tenure, i.e., rental accommodation ($\overline{Q}_t$) and uncertainty about its future course ($\sigma_{\overline{Q}}$), is also relevant to the house purchase decision.

7.

$$YP = \beta \sum_{i=0}^{n} (1 - \beta)^i Y_{t-i}$$

where Y is real GNP. Preliminary experimentation indicated that the optimal values for β and n are 0.6 and 4, respectively. Note that the time unit of the study is a quarter.

3.1 Estimating $\overline{P}_t$, $\overline{Q}_t$, $(\sigma_{\overline{P}})_t$, $(\sigma_{\overline{Q}})_t$

Estimates of the expected values of the two competing and mutually exclusive modes of tenure ($\overline{P}$ and $\overline{Q}$) are obtained using the optimal ARIMA forecasting technique developed by Box and Jenkins (1970). These forecasts are rational if past values of the variable in question contain all relevant information. The forecasting procedure adopted was the following: ARIMA models for P_t and Q_t were estimated for the full time period (i.e., 1968 Q1 to 1985 Q4). Our estimated models which yield white noise residuals and parameter values which do not violate stationarity nor invertibility conditions are:

$$(1 - 0.213\ B^1)(1 - B)(1 - B^4)P_t = (1 + 0.887\ B^1)(1 + 0.866\ B^4)\epsilon_t \quad (16)$$
$$(-1.65) \qquad\qquad\qquad (12.25) \qquad (17.4)$$

$$R^2 = 0.734;\ Q(24) = 22.10[\chi^2_{.95}(24\ \text{d.f.}) = 36.42]$$

$$(1 - B)(1 - B^4)Q_t = (1 + 0.640\ B^4)\epsilon_t \qquad\qquad\qquad (17)$$
$$(5.17)$$

$$R^2 = 0.271;\ Q(8) = 6.48[\chi^2_{.95}(8\ \text{d.f.}) = 15.51]$$

Further diagnostic checking consisted of fitting extra coefficients to the two models (as recommended by Granger and Newbold (1977)). However, this did not justify any doubts about the adequacy of the representations in Equations (16) and (17).

We next assume that potential homeowners form expectations about P and Q three years, or twelve quarters, into the future.[8] They use the underlying stochastic and time-invariant generating mechanisms of P and Q, estimates of which are given in Equations (16) and (17) above, to forecast P and Q. They are assumed to forecast periods T+1 to T+12 using data from period 0 to T but in no case are they assumed to use more than 20 previous quarterly values. They then take the average of the 12 forecast values as estimates of $\overline{P}$ and $\overline{Q}$.

Forecast error variances for P and Q cannot be obtained by adopting the procedure used, for example, by Rosen, Rosen and Haltz-Eakin (1984). Their forecast error variance is based on the period T estimate of the variance of the error term for the process (i.e., σ_T^2). Since our model is not re-estimated for each observation, such an approach is infeasible. An alternative approach is called for which we now explain.

Agents planning the purchase of a house will have been formulating hold-

---

8. It could perhaps be argued that, since renting requires a lower level of commitment in terms of transactions costs, the time horizon for $\overline{Q}$ should be shorter than that for $\overline{P}$.

ing cost expectations and comparing these with the actual outcomes over a protracted period in the past before the actual date of purchase. In each of these quarters, agents will have forecast the one-period-ahead holding cost and by comparing these with the actual outcomes will have been in a position to formulate some idea of the dispersion of the real holding costs which actually materialise around these forecasts. Thus we use the following formula to approximate subjective uncertainty about future holding costs:

$$(\sigma_{\overline{P}})_t = \sqrt{\frac{1}{n} \sum_{i=0}^{n-1} (A - F)^2_{t-i}}$$

where A is the actual value and F is the one-period-ahead forecast from the estimated ARIMA model in Equation (16). A value for n of five quarters seems reasonable. The expression $(\sigma_{\overline{Q}})_t$ is derived similarly. The idea here is simply that uncertainty experienced in the recent past is expected to characterise the near to medium-term future.

The remaining two variables in the equilibrium housing demand equation are local authority house completions (LAC) and a variable to represent the tilting effect on real mortgage repayments arising from the interaction of inflation with the standard mortgage. The first of these scarcely requires further comment except to note that we expect $c_5 < 0$. Further elaboration on the second is required, however.

3.2 *Inflation and the Tilt Effect*

A mortgage instrument characterised by a constant nominal payment accompanied by the anticipation of future inflation necessarily implies the expectation of a diminishing stream of real repayments throughout the life of the mortgage. Consequently, the initial payment must be sufficient to make up for this "tilt" effect so as to maintain unchanged, at the time of issue, the given real present value of the mortgage. This may force some borrowers into an intertemporal reallocation of lifetime consumption. Even with perfect capital markets (other than the mortgage market) this will be costly. Capital market imperfections will, of course, exacerbate the tilting effect.

In other words, before the moment of purchase, an increase in the anticipated rate of inflation, while not affecting the real cost of the mortgage when computed over the amortisation period, alters the profile of the real repayments stream by tilting the latter towards the early years of the mortgage. The basic reason for the tilt is straightforward. The type of financial instrument involved (i.e., the mortgage) requires the borrower to compensate the lender for inflation which is expected to occur in the future and which, if expectations are realised, will yield a gain to the borrower in terms of lower real

repayments only progressively throughout the twenty year life of the mortgage. In a world in which a household's ability to meet the annual payments is constrained by its current disposable income (there being little opportunity, as in the Irish case, of altering the level of gearing through secondary mortgages), the increase in the annual payment in the early years of the mortgage is bound to have a dampening effect on the demand for housing. This could take the form of postponing, forgoing or merely scaling down the level of demand. This tilting effect becomes more pronounced the greater the expected rate of inflation.

From the point of view of the borrower, the effective constraint on house purchase imposed by this reprofiling of real mortgage payments is the initial payment relative to disposable income. If, as argued by Irvine (1984), potential house purchasers can afford this initial payment, and choose to do so, then the payments *profile* is a *choice* variable and thus cannot enter as a further constraint on house purchase. The variable used by Kearl (1979) for a US study and Thom in a study with Irish data (1983) to approximate the tilting effect is the elasticity of the present value of a given stream of repayments with respect to the discount rate. The use of this variable along with the initial payments variable in the one regression relationship would seem to be mistaken. The distortion to the initial payment arising from the tilt relative to disposable income, our constraint variable, is:

$$ytilt = \frac{AL \cdot r_m / (1 - e^{-r_m T})}{(1 - \tau) \, 1.2 \, AIE}$$

where

AL   = average loan size granted by building societies
T   = amortisation period of initial loan (i.e., almost invariably 80 quarters)
τ = marginal tax rate of "typical" house purchasing unit
AIE   = average industrial earnings.

The ytilt ratio represents the proportion of the borrower's disposable income that is owed for the use of the borrowed funds. Irvine (1984) finds that the mean of the income distribution of new house purchasing mortgage recipients is 1.2 times average industrial earnings. Note that we are using the continuous time form in discounting to obtain the initial periodic payment as in Goodwin (1986) and that our representative or typical new house purchaser is assumed to be a married couple with no children.

In an ideal world of perfect capital markets, borrowers would be able to raise by other means the extra funds needed to overcome the tilt and repay this supplementary amount in later years of the mortgage when real mortgage

repayments fall. However, even in the most unlikely event that such uncollateralised borrowing were possible, it still constitutes an extra cost to be borne and hence will discourage house purchase. It is easy to demonstrate that fixed nominal repayment rate mortgages (i.e., the typical mortgage instrument in Ireland) are also subject to this tilting effect (see Modigliani and Lessard (1975)).

3.3 *Equations for Estimation*

Substituting Equation (14) into (15) and then into (12) and (13) yields the short-run or temporary equilibrium demand for real-valued mortgage advances, i.e.,

$$
\begin{aligned}
(MA/Ph)_t = {} & A_0 + A_1 YP_t + A_2 (\overline{P} - \overline{Q})_t + A_3 (\sigma_{\overline{P}} - \sigma_{\overline{Q}})_t + A_4 (ytilt)_t \\
& + A_5 (LAC)_t + A_6 H_{t-1} + A_7 (r_m - r_o)_t + A_8 (r_m - r_L)_t \\
& + A_9 (M/Ph)_{t-1} + A_{10} (SAV)_t + A_{11} (DR)_t \\
& + \sum_{k=4}^{n} A_k (A/P)_{kt-1} + \omega_t
\end{aligned}
\tag{18}
$$

Substituting Equation (10) into (11) gives us the corresponding supply schedule, i.e.,

$$
\begin{aligned}
(MA/Ph)_t = {} & B_0 (SAR/Ph)_t + B_1 (r_m - r_{IB})_t + B_2 V(Ph)_t + B_3 (REP/Ph)_t \\
& + B_4 (M/Ph)_{t-1} + B_5 (LR - \overline{LR})_{t-1} + B_6 DR_t + v_t
\end{aligned}
\tag{19}
$$

The supply equation is exactly identified but the demand equation is underidentified as can be easily seen from the relationship between the reduced form and structural parameters given in Appendix B. However, the crucial structural parameters in the demand equation from the point of view of the test for dynamic disequilibrium (i.e., b_2) is identified.

Finally, before estimation we integrate the price adjustment equations in (6a) and (6b) into Equations (18) and (19) which are the fleshed out versions of Equations (1) and (2), respectively. Doing this adds the "positive" switch variable to the demand schedule and the "negative" switch variable to the supply schedule.

IV EMPIRICAL RESULTS

Following the Hendry (1984) philosophy, an exhaustive search for lagged values of the conditioning variables (up to 6 quarters) in Equations (18) and

(19) was carried out. Of the variables in the demand schedule, none of the following was significant either contemporaneously or lagged: LAC, H, $r_m - r_o$, $r_m - r_L$, SAV. Furthermore, none of the one-period lags on A_k, $k = 1 \ldots . n$, was statistically significant. All of the variables in Equation (19) were statistically significant (SAR/Ph) with a one-period lag and $(r_m - r_{IB})$ with a three-period lag. The estimation was carried out using instrumental variables for DR and the switch variables Δr_{mt}^+ and Δr_{mt}^-. The model's exogenous variables and lagged values of these were used as instruments. However, given the step function nature of the switch variables, Fair and Jaffee (1972) note that a consistent procedure requires that the first stage regression be carried out only over that part of the sample for which Δr_{mt} is non-negative, to obtain an instrumental variable for Δr_{mt}^+, and only over that part of the sample for which Δr_{mt} is non-positive, to obtain one for Δr_{mt}^-.

Equations (1) and (3) in Table 2 constitute our estimate of the disequilibrium model. The instrumental variables for DR, Δr_{mt}^+ and Δr_{mt}^- are denoted by a circumflex over these variables. The statistical fit of both equations is satisfactory. In the demand equation, the Durbin-Watson statistic[9] indicates the absence of first-order autocorrelation and the Ljung-Box Q tests also indicate the absence of first and higher order autocorrelation at the 5 per cent level but not at the more stringent 10 per cent level. All variables are correctly signed. They are also all significant at 1 per cent level except for the second lag on the relative risk variable and the switch variable, both of which are comfortably significant at the 10 per cent level. In the supply equation (i.e., Equation (3) in Table 2) the Q tests fail to reject the null of no autocorrelation up to four and eight displacements at the stringent 10 per cent level of significance. Again, as with the demand equation, all variables are signed according to theory. With the exceptions of the switch variable and the lagged repayments variable, all the variables are significant at the 5 per cent level and with the one exception of lagged repayments, the remainder are significant at the 1 per cent level. The importance of the downpayment ratio in both schedules is of particular significance in attempting to carry out a test for price disequilibrium. This is an issue that warrants closer scrutiny.

4.1 Sluggish Price and Non-Price Terms

Consult Figure 1. Excess demand at the opening of period t at mortgage interest rate $_{t-1}r_{mt}$ is AD. If this pressure of excess demand is sufficient to drive the mortgage rate to $_t r_{mt}$ before the end of period t (in accordance with the partial price adjustment theory in Equation (6a) of Section II), then CD customers exit from the market. The customers indicated by AB have their

---

9. The DW statistic is valid here since $(MA/Ph)_{t-1}$ is not a right-hand-side argument in the equations.

Table 2: *Disequilibrium Mortgage Market Results*
(Absolute t values in parentheses)

	Demand			Supply	
	(1) $(MA/Ph)_t$	(2) $(MA/Ph)_t^A$		(3) $(MA/Ph)_t$	(4) $(MA/Ph)_t^A$
Constant	7.96 (2.73)	5.96 (2.13)	$(SAR/Ph)_{t-1}$	0.362 (9.94)	0.356 (13.17)
YP_t	0.017 (4.40)	0.020 (6.48)	$(r_m - r_{IB})_{t-3}$	0.242 (3.83)	0.285 (4.41)
$(\overline{P} - \overline{Q})_{t-5}$	-0.013 (5.16)	-0.013 (5.04)	$V(Ph)_t$	-9.73 (5.95)	-9.81 (11.86)
$(\sigma_{\overline{P}} - \sigma_{\overline{Q}})_{t-3}$	-0.004 (3.65)	-0.003 (3.83)	$(M/Ph)_{t-1}$	-0.42 (9.38)	-0.41 (12.26)
$(\sigma_{\overline{P}} - \sigma_{\overline{Q}})_{t-5}$	-0.002 (1.81)	-0.002 (1.52)	$(LR - \overline{LR})_{t-1}$	-30.43 (6.02)	-33.15 (7.04)
$(ytilt)_{t-1}$	-22.57 (4.32)	-23.23 (4.57)	$(REP/Ph)_t$	0.49 (2.26)	0.47 (2.20)
$(M/Ph)_{t-1}$	-0.02 (3.26)	-0.02 (3.88)	$(REP/Ph)_{t-1}$	0.37 (1.73)	0.35 (1.68)
$\hat{DR}_t$	-20.77 (2.96)	—	$\hat{DR}_t$	18.65 (10.66)	—
$\hat{\Delta r}^+_{mt}$	-0.901 (1.78)	-1.081 (2.23)	$\hat{\Delta r}^-_{mt}$	0.07 (0.19)	0.11 (0.29)
$\overline{R}^2$	0.870	0.878		0.889	0.900
% SER	9.9	9.7		9.2	9.4
F(/)	(8/45) 45.2	(7/46) 55.3		(8/45) 53.9	(7/46) 69.2
DW	1.86	1.95		1.83	1.92
Q(8)	13.74	9.30		5.74	5.23
Q(4)	10.13	7.50		0.41	0.65

demands satisfied while the demands of BC customers remain frustrated. At the opening of period t all AD customers are willing to pay a price for mortgage credit which is strictly greater than $_{t-1}r_{mt}$, i.e., they are willing to pay

the relevant *virtual* rate of interest (see Neary and Roberts (1980)) which in each case is strictly greater than $_{t-1}r_{mt}$. At the end of period t, BC customers are willing to pay virtual rates which are all strictly greater than the closing period rate $_t r_{mt}$. So the question naturally arises as to what screening devices are used by the building societies to select a subset from a larger total of customers, all of whom are willing to pay a rate in excess of that being charged by the building societies. Several such non-interest rate screening devices have been suggested in the literature. Huang (1966), Sparks (1967), Smith (1969), Dhrymes and Taubman (1969), Silber (1970) and Ostas and Zahn (1975) have all employed *non-interest credit terms* as a means of accounting for non-interest credit rationing effects. For example, Smith used the yield differential on mortgages and bonds to represent non-interest credit rationing effects, Silber used the amortisation rate while Dhrymes and Taubman employed maturity. Ostas and Zahn used the downpayment ratio or the equity contribution of the mortgage demander to house purchase. We also employ the downpayment ratio while not denying the potential importance of those other non-price terms..

Figure 1: *The Downpayment Ratio and the Mortgage Market*
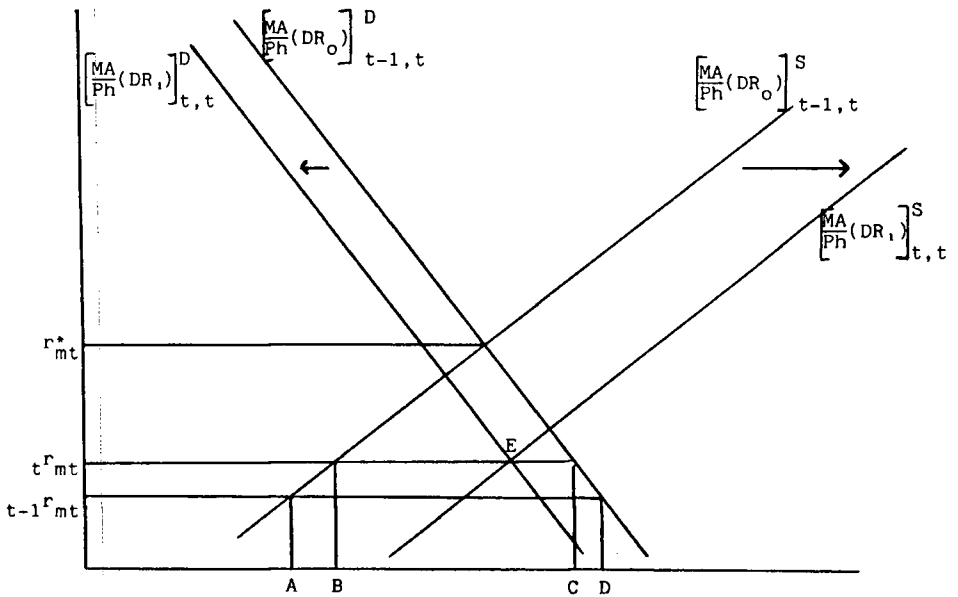
In a price disequilibrium situation, an increase in DR *offered* by potential borrowers who find themselves price-rationed is seen, from the perspective of the building society, as an improvement in the mix of borrowers. Thus, at any given sluggish mortgage rate, building societies are willing to supply

more mortgages, i.e., the supply schedule shifts to the right. Analogously, an increase in DR *required* by building societies causes the mortgage demand schedule to shift to the left.

If the mortgage market clears in the long run by movements in r_m alone (a not unreasonable maintained hypothesis), then movements in non-price terms, such as DR, play no part in long-run market equilibrium (refer to Equations (10) and (12) in Table 1). The role of DR is strictly a short-run one which is invoked by the very sluggishness of r_m itself. However, the endogenous response of the downpayment ratio D̂R to price disequilibrium (if it exists) presents considerable econometric difficulties in testing for price disequilibrium itself. The shifted demand and supply schedules may intersect at the prevailing sticky mortgage rate and thereby indicate market clearing, i.e., at point E in Figure 1. Thus *allowing* for this endogenous response of DR which, in turn, arises from *ex ante* price disequilibrium may impose *de facto* price equilibrium on the model and hence bias the test in favour of the market-clearing hypothesis.

Thus to test for price disequilibrium, the objective must be to, first, sterilise for the effects of contemporaneous *changes* in DR on demand and supply. This is achieved by excluding D̂R$_t$ from the right-hand side of the demand and supply equations, correcting the respective dependent variables as follows:

$$(MA/Ph)^A_t = (MA/Ph)_t + 20.77 DR_{t-1} ,$$

$$(MA/Ph)^A_t = (MA/Ph)_t - 18.65 DR_{t-1} ,$$

and re-estimating. The numbers 20.77 and 18.65 are the IV estimates for DR$_t$ in Table 2. The results of this procedure are reported in Equations (2) and (4) in Table 2. The demand equation coefficients remain largely unaltered except for that on the switch variable which is now easily significant at the 5 per cent level. Also the Ljung-Box Q tests now fail to reject no autocorrelation at the demanding 10 per cent level. The t values on the supply equation coefficients have almost all improved, some quite dramatically. However, that on the switch variable remains well short of statistical significance.

Now, combining the results for this adjusted model and using the relationships in Equation (9) in Section II above,[10] along with the formulae for calculating the respective standard errors, we obtain the following estimates of Equations (6a) and (6b) in Section II (the figure in parenthesis is an estimated t value):

---

10. Note that although neither $r_m - r_o$ nor $r_m - r_L$ are significant in the demand schedule, $\hat{\alpha}_2$ is not zero since r_m is a component of P and thus of $\bar{P}$.

$$r_{mt} = 0.78\, r_{mt-1} + 0.22\, r^*_{mt}, \text{ in an excess demand regime,}$$
$$(9.22)$$

$$r_{mt} = r^*_{mt}, \text{ in an incipient excess supply regime.}$$

This result conforms with conventional wisdom. We find no evidence of dynamic excess supply. In an excess demand regime, on the other hand, the mortgage rate changes by only 22 per cent of the difference between last period's rate and the current market-clearing rate on average. Note that $\hat{\mu}_1$ is significantly different from both 0 and 1 at the 1 per cent level.

Given this sluggish price movement in an excess demand regime, it is not surprising that the one non-price factor we have identified plays such an important short-run role in market clearing.[11] Our results and approach here suggest an interesting perspective on a paper by Ostas and Zahn (1975) also dealing with the role of the downpayment ratio in mortgage market clearing. They say: "Although in the short run the downpayment ratio *alone* clears the market, in the long run the mortgage rate equilibrates the market at a level consistent with the long-run downpayment ratio" (p. 193, italics added). Of course, if the downpayment ratio *alone* clears the market in the short run the adjustment of $_{t-1}r_t$ to r^*_t in Figure 1 is of a once-off nature at the point in time when DR re-attains its long-run equilibrium level rather than of the gradual sluggish type suggested by Ostas and Zahn themselves. Our own approach here departs from that of Ostas and Zahn in allowing for both the mortgage rate *and* the downpayment ratio to contribute to clearing the mortgage market in any one time period. Furthermore, Ostas and Zahn do not test their theory simply because they could not have done so given their model. The only conclusion they could legitimately have inferred from their results (but did not) was that endogenous variations in the downpayment ratio (DR) *contribute* to market clearing. Likewise here. We can comfortably accept the view that the Irish mortgage market is in disequilibrium, that variations in the mortgage rate of interest make a relatively small contribution, on average, to closing the opening-period *ex ante* supply-demand gap in an excess demand regime and that shifts in the supply and demand schedules arising from endogenous variations in the downpayment ratio also contribute to closing the gap. We are further enabled to conclude that the mortgage market is cleared *solely* by variation in the mortgage rate *in the long run*. We are not, however, in a position to say that the mortgage market clears in the

11. It is noteworthy, however, that not all researchers (for example, Nellis and Thom, 1986) into the process of mortgage market clearing attribute the same role to non-price aspects. The latter argue that variations in non-interest rate terms determine which borrowers are accommodated, but do not shift the demand curve nor, presumably, the supply curve.

short run through a combination of changes in the mortgage rate and the downpayment ratio. In other words, referring back to Figure 1 above, we cannot be sure, and we have no way of rigorously testing, whether the shifted mortgage demand and supply schedules with the new DR values intersect at the level of the mortgage rate which is attained by the end of current quarter, i.e., at point E. Variation in other non-price terms may be required to guarantee this.

The short-run elasticities of the flow demand for real-valued mortgage advances with respect to permanent income, the expected user cost of housing, the variability of the cost of home-owning relative to that of rental accommodation, the tilt and the downpayment ratio are the following: 2.04, -0.00175, -0.196, -0.675 and -0.81. The permanent income elasticity seems to be somewhat on the high side. Apart from this, the remaining variables have not previously been employed in mortgage demand estimation. Thus, comparisons cannot be made and prior expectations are consequently also somewhat diffuse. Note also that only short-run elasticity estimates are being reported for demand. Given the tiny estimate obtained for ϕ_1 (i.e., 0.02) and the insignificance of ϕ_k, $k = 1, \ldots, n$, long-run elasticity estimates are all implausibly large.

The long-run supply elasticities estimated for the disequilibrium model are the following: 14.97 for real-valued share accounts, 0.66 for the mortgage rate of interest, -0.59 for house price variability, 0.51 for real-valued mortgage repayments and 1.72 for the downpayment ratio. This first elasticity is not implausible when account is taken of the stock-flow nature of the supply equation. A 10 per cent increase in (SAR/Ph), from say IR£172.76 million (i.e., the mean value over the estimation period) to IR£190.04 million, i.e., an increase of IR£17.28 million, leads to an increase in real mortgage supply (MA/Ph) of 149.7 per cent., i.e., from a mean value of IR£9.98 million to a value of IR£27.82 million (an increase of IR£17.86 million). Allowing for some statistical inaccuracies, this says that a pound increase in resources will ultimately lead to a one pound increase in mortgage advances.

A 10 per cent short-run increase in the liquidity ratio over its equilibrium level ($\overline{\text{LR}}$) leads to a 7.6 per cent reduction in the flow supply of real-valued mortgage advances. The calculation of a corresponding long-run elasticity here makes no sense since, in the long run, LR = $\overline{\text{LR}}$.

The difference between the fitted values of Equations (2) and (4) in Table 2 yields our estimate of dynamic[12] excess mortgage demand in real house purchasing terms. A time series plot of this is presented in Figure 2. The picture that emerges is that, as a general rule, the level of excess mortgage demand varies procyclically.

12. Dynamic credit or mortgage rationing should be contrasted with equilibrium rationing as discussed, for example, by Stiglitz and Weiss (1981), in which rationing can occur when $r_{mt} = r^*_{mt}$.

Figure 2: *Dynamic Excess Mortgage Demand in Real House Purchasing Terms*
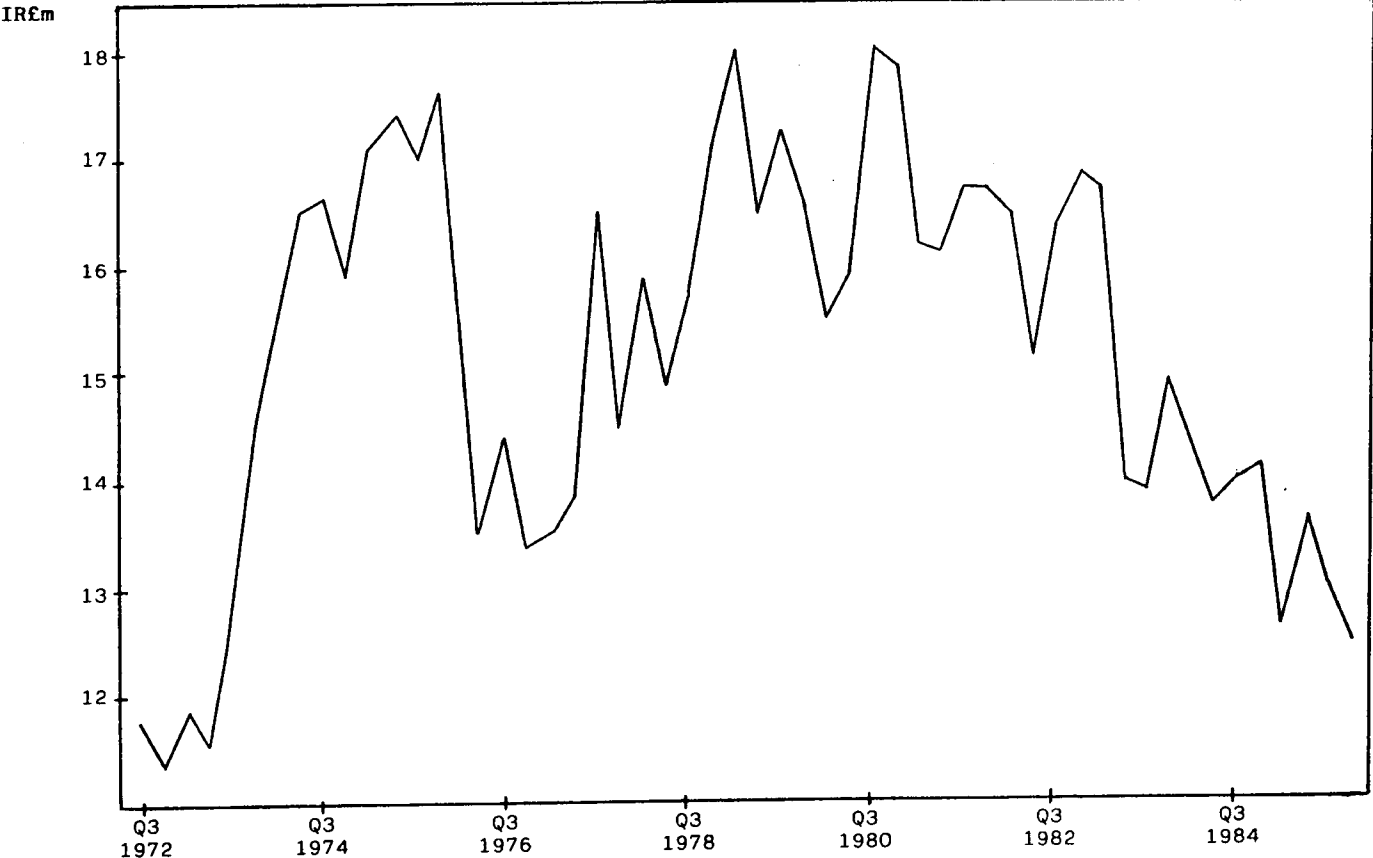
V CONCLUSIONS

The equilibrium hypothesis for the Irish mortgage market is decisively rejected. The dynamic disequilibrium is exclusively due to upward sluggishness of the mortgage rate of interest. In an incipient excess supply regime, the mortgage rate is adjusted downwards to its equilibrium level within a quarter of a year. This asymmetry in the speed of adjustment of the rate to its market-clearing value suggests that it is largely political pressures which prevent the mortgage rate rising. Generally speaking, more potential house purchasers could obtain mortgages, or successful applicants could obtain larger mortgages, if the mortgage rate were *increased* to its market-clearing value more promptly.

In situations in which the building society cartel fails to raise, or is prevented from raising, the mortgage rate to its market-clearing level, it will face a queue of borrowers all of whom are willing to pay a price in excess of that being charged. Only a subset of this queue will have their demands satisfied. What criterion do agents on the short side of the market (building societies) use to select demanders from the queue? Each agent in the queue has a different probability of defaulting on the mortgage loan. Therefore it would make little sense for a building society to select demanders from the queue on a random basis. Doing so, it would probably forfeit more profitable opportunities in not choosing the lower risk candidates. It is hypothesised that building societies will select demanders from the queue on the basis of some non-price mortgage terms. The particular non-price mortgage term we choose to look at is the downpayment ratio (i.e., the equity contribution/house price ratio). When mortgages are in excess demand, building societies will *require* a larger downpayment ratio of successful customers. Some customers will be unable to meet this more stringent downpayment ratio requirement and will therefore be rationed from the market. Also an increased downpayment ratio *offered* by a customer will increase his chances of obtaining a loan.

In brief, the downpayment ratio reacts *endogenously* to mortgage market disequilibrium to reduce demand and increase supply in an excess demand regime. The existence of this mechanism is strongly supported by our results. We can therefore conclude that both the downpayment ratio and the mortgage interest rate itself make a *contribution* to clearing the mortgage market in the short run.

However, variation in the non-price term *consequent* on price rationing causes the demand and supply schedules to shift in such a way as to bias the test used here in favour of the market-clearing hypothesis. We tackled this problem by sterilising the demand and supply schedules of contemporaneous movements in the non-price term, i.e., the downpayment ratio. Re-estimation under these conditions yielded all-round improved results.

Available evidence would suggest that monetary policy in Ireland has no enduring effect on those areas of activity which are financed by bank credit. This is because money and credit are internationally tradable assets and hence an artificial shortage (surplus) of these created by domestic monetary policy in the interests of pursuing some domestic macroeconomic objective will eventually be negated by the international movement of liquid claims. The one area of economic endeavour which may have to be excepted from this conclusion relates to the mortgage and housing markets. Mortgages are generally not (yet) tradable internationally. Hence mortgage market dis-equilibrium cannot be offset by a supply of close substitutes from abroad. Therefore, one of the major channels of transmission of monetary disturbances, whether of domestic or foreign origin, is via mortgage market disequilibrium to the housing market. The fact that the housing market is subject to such huge cyclical variation in activity may be due in no small way to the fact that it is hostage to those monetary shocks.

REFERENCES

ANDERSON, G.J., and D.F. HENDRY, 1984. "An Econometric Model of United Kingdom Building Societies", *Oxford Bulletin of Economics and Statistics*, Vol. 46, No. 3, August, pp. 185-209.

BOWDEN, ROGER J., 1978. "Specification, Estimation and Inference for Models of Markets in Disequilibrium", *International Economic Review*, Vol. 19, October, pp. 711-726.

BOX, G.E.P., and G.N. JENKINS, 1970. *Time Series Analysis, Forecasting and Control*, San Francisco: Holden Day.

BRAINARD, W.C., and J. TOBIN, 1968. "Pitfalls in Financial Model Building", *American Economic Review*, Vol. 57, No. 2, May, pp. 99-121.

BRECHLING, F., 1975. *Investment and Employment Decisions*, Manchester: Manchester University Press.

BROWNE, F.X., 1986. "A Monthly Money Market Model for Ireland in the EMS", *Central Bank of Ireland Annual Report*, Spring, pp. 76-117.

BROWNE, F.X., 1987. "Sluggish Quantity Adjustment in a Non-Clearing Market — A Disequilibrium Econometric Application to the Loan Market", *Journal of Applied Econometrics*, Vol. 2, No. 4, October, pp. 335-348.

BROWNE, F.X., and P. HONOHAN, 1988. "Modelling the Portfolio Behaviour of Selected Financial Intermediaries in Ireland", *Economic Modelling*, Vol. 5, No. 1, pp. 9-18.

CHAREMZA, WOJCIECH, 1979. "Some Comments on a Bowden Model of Market in Disequilibrium", Institute of Economic Cybernetics and Informatics Discussion Paper in Econometrics and Statistics, No. 2, University of Gdansk.

DAVIS, E.P., and I.D. SAVILLE, 1982. "Mortgage Lending and the Housing Market", *Bank of England Quarterly Bulletin*, Vol. 22, No. 3, September, pp. 390-398.

DHRYMES, P.J., and P.J. TAUBMAN, 1969. "An Empirical Analysis of the Savings and Loan Industry", in I. Friend (ed.), *Study of the Savings and Loan Industry*, Vol. 1, Washington: Federal Home Loan Bank Board, pp. 69-183.

FAIR, R.C., and D.M. JAFFEE, 1972. "Methods of Estimation for Markets in Disequilibrium", *Econometrica*, Vol. 40, May, pp. 497-514.

FRIEDMAN, BENJAMIN M., 1977. "Financial Flow Variables and the Short-Run Determination of Long-Term Interest-Rates", *Journal of Political Economy*, Vol. 85, August, pp. 661-689.

FRIEND, I. (ed.), 1969. *Study of the Savings and Loan Industry*, Washington: Federal Home Loan Bank Board.

GOODWIN, T.H., 1986. "Inflation, Risk, Taxes and the Demand for Owner-occupied Housing", *Review of Economics and Statistics*, May, pp. 197-206.

GRANGER, C., and P. NEWBOLD, 1977. *Forecasting Economic Time Series*, New York, San Francisco and London: Academic Press.

HENDRY, F.D., 1984. "Econometric Modelling of House Prices in the United Kingdom", in D.F. Hendry and K.F. Wallis (eds.), *Econometrics and Quantitative Economics*, Oxford: Basil Blackwell, Chapter 8, pp. 211-252.

HUANG, D.S., 1966. "The Short Run Flow of Non-Farm Residential Mortgage Credit", *Econometrica*, Vol. 34, pp. 433-459.

IRVINE, I., 1984. *A Study of New House Prices in Ireland in the 'Seventies*, Dublin: The Economic and Social Research Institute, Paper No. 118, December.

ITO, TAKOTOSHI, and KAZUO UEDA, 1981. "Tests of the Equilibrium Hypothesis in Disequilibrium Econometrics: An International Comparison of Credit Rationing", *International Economic Review*, Vol. 22, No. 3, October, pp. 691-708.

JAFFEE, D.M., and K.T. ROSEN, 1979. "Mortgage Credit Availability and Residential Construction", *Brookings Papers on Economic Activity*, No. 2, pp. 333-376.

JORGENSON, D.W., 1971. "Econometric Studies of Investment Behaviour: A Survey", *The Journal of Economic Literature*, Vol. 9, December, pp. 1111-1147.

KEARL, J.R., 1979. "Inflation, Mortgages and Housing", *Journal of Political Economy*, Vol. 87, No. 5, pp. 1115-1138.

MODIGLIANI, F., and D. LESSARD, (eds.), 1975. *New Mortgage Designs for Stable Housing in an Inflationary Environment*, The Federal Reserve Bank of Boston Conference Series No. 14, January.

NEARY, J.P., and K.W.S. ROBERTS, 1980. "The Theory of Household Behaviour under Rationing", *European Economic Review*, Vol. 13, No. 1, January, pp. 25-42.

NELLIS, J.G., and R. THOM, 1986. "The Nature of Credit Rationing in the United Kingdom Mortgage Market", *Journal of Urban Economics*, No. 20, pp. 39-54.

OSTAS, J.R., and F. ZAHN, 1975. "Interest and Non-Interest Credit Rationing in the Mortgage Market", *Journal of Monetary Economics*, pp. 187-201.

ROSEN, H.S., and K.T. ROSEN, 1980. "Federal Taxes and Homeownership: Evidence from Time Series", *Journal of Political Economy*, Vol. 88, No. 1, February, pp. 59-75.

ROSEN, H.S., K.T. ROSEN, and D. HALTZ-EAKIN, 1984. "Housing Tenure, Uncertainty and Taxation", *The Review of Economics and Statistics*, No. 66, August, pp. 405-416.

SILBER, W.L., 1970. *Portfolio Behaviour of Financial Institutions*, New York: Holt, Rinehart and Winston.

SMITH, L.B., 1969. "A Model of the Canadian Housing and Mortgage Markets", *The Journal of Political Economy*, Vol. 77, September, pp. 795-816.

SMITH, G., 1975. "Pitfalls in Financial Model Building: A Clarification", *American Economic Review*, Vol. 65, pp. 510-516.

SPARKS, G.R., 1967. "An Econometric Analysis of the Role of Financial Intermediaries in Postwar Residential Building Cycles", in R.F. Ferber (ed.), *Determinants of Investment Behaviour*, New York: National Bureau of Economic Research, pp. 302-324.

STIGLITZ, J.E., and A. WEISS, 1981. "Credit Rationing in Markets with Imperfect Information", *American Economic Review*, Vol. 71, No. 3, June, pp. 393-410.
THOM, R., 1983. "House Prices, Inflation and the Mortgage Market", *The Economic and Social Review*, Vol. 15, No. 1, October, pp. 57-68.

APPENDIX A

Calculation of P

Computing the costs of owner-occupation is complicated by the fact that owners do not pay an explicit rent for housing in each period and hence, of course, the purchase price and the holding cost are not the same thing. The formula used to derive an *ex post* holding cost is taken from neoclassical investment theory (see Jorgenson (1971) and, for a survey, Brechling (1975)). However, the derivation of the user cost in the case of owner-occupied housing is in some respects more complicated than in the case of a corporate enterprise because the former varies depending upon the circumstances of the individual house purchaser. One reason for this is that the tax and subsidy regulations pertaining to mortgage and house purchase vary depending upon, for example, the marital status of the individual and on whether he/she is a first-time or second-time house purchaser (see Irvine (1984) for a more detailed account of the Irish case). Thus what is called for is the construction of a cost of capital series for a typical potential house purchaser. This typical unit is assumed to be a married couple with no children.

The tax/subsidy arrangements encouraging homeownership in force in Ireland up to the end of 1985 (i.e., the end of our sample period) were the following:

(1) the total exemption of capital gains on the primary residence from taxation;

(2) the exemption from taxation of implicit rental income accruing to the homeowner;

(3) the deductibility of mortgage interest payments from taxable income. There was no upper limit to the amount deductible before 1974. After this date up to £4,000 was deductible for a married couple,

(4) a grant of £1,000 for a first-time buyer of a new house operative since 1978. This was altered to £2,000 in 1983;

(5) a £3,000 mortgage subsidy distributed over a five-year period (when initially introduced in 1981, the same amount was distributed over a three-year period);

(6) and, finally, property taxes, except for a very small segment of the market, were eliminated in 1977.

The real *ex post* net user cost of housing capital for the typical unit is P_t where:

$$P_t \quad = P_{nt}/CPI \tag{A1}$$

$$P_{nt} \quad = (1 - \sigma\tau)P_{gt} \tag{A2}$$

$$\begin{aligned}P_{gt} \quad &= \psi r_{ct}Ph_t + (1 - \psi)[r_{mt}Ph_t - MS_t] \\ &\quad - \dot{Ph}_t + D_t + M_t + T_t\end{aligned} \tag{A3}$$

$$\sigma \quad = (\psi r_{ct}Ph_t + (1 - \psi)r_{mt}Ph_t)/P_{gt} \tag{A4}$$

$$\psi \quad = 1 - (als - Gr) \tag{A5}$$

$$D_t + M_t = 0.005Ph_t \tag{A6}$$

$$MS_t \quad = \sum_{i=1}^{n} Ai/(1 + r)^i$$

$n = 3$, $A_1 = £1,500$, $A_2 = £1,000$, $A_3 = £500$
from 1981 Q1 to 1982 Q1

$n = 5$, $A_1 = £1,000$, $A_2 = £800$, $A_3 = £600$,
$A_4 = £400$, $A_5 = £200$
from 1982 Q2 to end of sample period.

$$\left. \right\} \tag{A7}$$

P_{nt} is the net nominal effective and P_{gt} the gross nominal effective holding cost. σ is the fraction of the cost of housing capital that is tax deductible. ψ is the fraction of the house price financed by equity capital on average where als is average loan size relative to Ph and Gr is the value of Government grants accruable to the typical potential purchaser. The first term on the right-hand side of Equation (A3) is therefore the total opportunity cost of equity capital committed to house purchase. r_c is the bank deposit rate of interest. $(1 - \psi)r_{mt}Ph_t$ is the direct cost of mortgage finance. MS_t is the present value of the mortgage subsidy defined in Equation (A7). The number of years over which the grant was payable was altered in 1982 as indicated in Equation (A7). Since capital gains are tax exempt, ΔPh_t attracts a coefficient of minus one in the P_g formula. Ph in (A3) has been adjusted for quality changes except for the ΔPh term. T is property taxes which, for the purposes of the present analysis, are ignored. Their importance is diminished by the fact that rates remission was available on new houses for most of the sample period up to 1977 when rates were abolished.

Following Rosen and Rosen (1980) and in keeping with real estate practice, we assume depreciation and maintenance to be each 1 per cent of house value or ½ per cent combined per quarter year (see Equation (A6)). Implicit

service income $(\psi r_{ct} Ph_t)$ accruing to the owner *as* occupier is not taxed and hence is included, along with *total* mortgage interest payable on the average mortgage in the numerator of Equation (A4). Since the ceiling on the maximum mortgage interest deductibility (£4,000) was introduced in 1974, it has always exceeded the maximum mortgage interest payable by our typical potential house purchaser. A record high mortgage rate of 16.25 per cent occurred in 1982 implying an annual interest payment of approximately £3,700 on the average mortgage. Therefore, we include total mortgage interest payments in the numerator of Equation (A4). Further details on the calculation of P_t can be had in Irvine (1984).

APPENDIX B

Relationship Between Structural and Reduced-form Parameters

$$A_0 = \phi_1(b_0 + b_1 \theta c_0)$$

$$A_1 = \phi_1 b_1 \theta c_1$$

$$A_2 = \phi_1 b_1 \theta c_2$$

$$A_3 = \phi_1 b_1 \theta c_3$$

$$A_4 = \phi_1 b_1 \theta c_4$$

$$A_5 = \phi_1 b_1 \theta c_5$$

$$A_6 = \phi_1 b_1 (1 - \theta)$$

$$A_7 = \phi_1 b_2$$

$$A_8 = \phi_1 b_3$$

$$A_9 = \phi_1$$

$$A_{10} = \phi_2$$

$$A_{11} = \phi_3$$

$$A_k = \phi_K, \, k = 4, \ldots, n$$

$$B_0 = \delta_1 a_0$$

$$B_1 = \delta_1 a_1$$

$$B_2 = \delta_1 a_2$$

$$B_3 = \delta_1 a_3$$

$$B_4 = -\delta_1$$

$$B_5 = \delta_2$$

$$B_6 = \delta_3$$