

# A Preliminary Econometric Investigation of the Irish Housing Market, 1969-1976

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*Précis:* Recent modelling developments in the housing economics literature are reviewed and drawn on to construct a national housing model for Ireland. The model is estimated on quarterly data over the period 1969-1976. The estimation results, with some exceptions, are satisfactory. On the basis of the results it is concluded, tentatively, that policies directed at lowering the cost of housing capital exert a strong influence on house prices but have little effect on output. Finally, some areas for future improvements in data construction and model specification are identified.

## I INTRODUCTION

The Irish housing market has attracted considerable attention in recent years. Baker and O'Brien (1979) have provided an overview of the housing system. The private letting sector has been considered by the Threshold Report (1982) while selected housing policies operated by the government have been analysed by the National Economic and Social Council (NESC, 1977), McKeon and Jennings (1978) and Jennings (1980). A comparative and historical profile of the stock of Irish dwellings has been reported by Pratschke (1978). In addition the construction industry which serves the housing market has been examined by Wrigley and McCarthy (1981) and the related mortgage market has been the subject of several studies (Hewitt and Thom, 1979, O'Loughlin, 1980 and Kenneally, 1982). To date, however, no published study of the formal structure of the Irish housing market is available.<sup>1</sup>

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1. An unpublished study by Nolan is, however, available (see references).

The present paper attempts to remedy this deficiency by constructing and estimating an econometric model of the private housing market. The key variables which the model seeks to explain are private housing starts, private house completions and new house prices.<sup>2</sup> We have concentrated on constructing a model, to explain these variables, which has satisfactory micro-theoretic foundations. The empirical implementation of the model is, in certain respects, somewhat incomplete, because the availability and quality of published housing statistics impose constraints on both the period over which the model is estimated and the accuracy with which a number of the model variables are measured or approximated. We have chosen, by and large, to accept these constraints rather than attempt to construct more satisfactory data series. The model estimates are, accordingly, preliminary and should be interpreted with caution. Section II of the paper considers some literature pertinent to the formulation of a housing market model. On the basis of these considerations a housing model is specified in Section III. The estimation results for the model and its tracking performance are discussed in Section IV. Part V offers some conclusions.

## II THEORETICAL CONSIDERATIONS

The purpose of this section is to provide an overview of some of the key developments in the literature. These are intended to guide the model specification undertaken in Section III.

Existing studies vary in their choice of dependent variable as between the number of housing units (quantity) and the financial outlays on housing units (expenditure). The objectives of this paper dictate the adoption of the former measure and the studies considered below are concentrated on those which fall within this category. Many of these take the form of subsectors of large scale macro-econometric models and have been criticised in a review by Fromm (1973, p. 130) for their *ad hoc* specification (see also McCarthy, 1981). They are, accordingly, considered on a selective basis.

Most housing studies implicitly assume a perfect elastic supply of housing. The flow demand for housing is generally characterised by a Nerlove partial adjustment of the actual housing stock to its desired level<sup>3</sup>, i.e.,

$$K_t^* = f(X_t) \quad (1)$$

$$\Delta K_t = a_0(K_t^* - K_{t-1}) + a_1 K_{t-1} \quad (2)$$

2. The history of these variables, over the sample period is presented in Graphs 1 to 4.

3. See, for example, Muth (1960), Lee (1964), Whitehead (1971, 1974), Kearl and Mishkin (1977), Borooah (1978), Follain (1979) and Jaffee and Rosen (1979). Muth *op. cit.*, provides a comprehensive rationalisation of this approach.

where  $K^*$  ( $K$ ) is the desired (actual) housing stock,  $\Delta K$  is the flow demand for housing,  $X$  is a vector of explanatory variables,  $a_0$  is the partial adjustment coefficient and  $a_1$  is the rate of replacement demand. While the stock adjustment approach has been popular, the choice and operational definitions of the explanatory variables (and associated elasticity estimates) have differed appreciably both across countries and over time. Price, income, household formation and cost of housing capital variables have generally been included, albeit in a variety of different forms, as determinants of the desired housing stock. Increasingly, a credit availability variable has also been incorporated (Lee, 1964; Whitehead, 1974; Kearl and Mishkin, 1977; Borooah, 1978) to allow for the crucial role of mortgage funds to potential house purchasers. Its inclusion is, however, open to criticism. Credit availability is unlikely to affect the *desired* housing stock. Its more probable effect is to advance or retard the effective flow demand for housing. It should, therefore, be more appropriately expressed as an argument of Equation (2).<sup>4</sup> Government policy also exerts an important role in housing demand. Robinson (1979, p. 10) notes "its policy . . . determines to some extent the terms on which all housing is demanded or supplied". Notwithstanding this widely agreed conclusion, few studies incorporate the effects of government policy (see Fromm, 1973 and McCarthy, 1981). The omission probably results from the range and complexity of government policies and the quality of data pertaining to them. Some policies, such as the provision of mortgage finance and public housing, directly affect the demand for private housing. Other policies, such as subsidies and tax reliefs<sup>5</sup> operate indirectly through their effects on the cost of housing capital. Policies of the latter type are particularly complex in their effects. In Ireland, for instance, they do not affect the cost of housing capital in a simple and unique manner but vary, in a complex fashion, according to the category of purchaser and type of house purchased. (See Irvine, 1982 for a comprehensive assessment.)

The supply of housing consists of the existing stock plus current completions and conversions less demolitions. The stock of private housing is additionally affected by sales of local authority houses to tenants. As the existing stock of housing is predetermined, it is the flow supply of housing which has been the focus of published research. This is taken, for convenience, (and due to the absence of satisfactory data on conversions and demolitions) as being identical to the number of house completions. As early as 1963 Grebler and Maisel (1963, p. 479) criticised the concentration of published analytical work on the demand side of the market— "The availability of land, building materials, labour and contractors and other entrepreneurs as

4. We are grateful to Colm McCarthy for drawing this point to our attention.

5. A comprehensive listing of the policies in force in Ireland is provided by McCarthy (1981).

well as an effective market organisation which allows all these input factors to be brought together is taken for granted". While some progress in this regard has been evident in recent years, supply side studies are, as yet, relatively few in number. Moreover, a sharp distinction exists between US and UK supply side studies mirroring differences in market arrangements as between the two countries. In the US "the majority of single family units are now custom built, self built or directly contracted in some manner." (See Jaffee and Rosen (1979, p. 339).) For this reason the supply side of the US housing market is normally characterised by a single equation determining the quantity supplied, which is usually taken as the number of housing starts. The relationship between housing starts and completions is generally ignored. In the UK "house builders normally construct private dwellings on a speculative basis", Borooah (1978, p. 2). For this reason the relationship between housing starts and completions is more complex than in the American case. Separate equations are generally specified for starts and completions with the time lag between them reflecting technical or economic factors or both. The similarity between Irish and UK supply side market arrangements suggests the approach adopted in UK studies is more relevant to our purpose.

Broad agreement exists in US studies on the specification of long-run (annual) housing starts' equations, i.e.,

$$HS_t = b_0 + b_1 PH_t + b_2 CM_t + b_3 W_t + b_4 r_t \quad (3)$$

where HS = housing starts, PH = house prices, CM = an index of construction material costs, W = wage costs and r = an interest rate. The explanatory variables are intended to reflect the perceived profitability of housing construction. Equations of this type have been estimated in a variety of studies.<sup>6</sup> While a number of these studies support the contention that the long-run supply of housing is perfectly elastic no such support may be gleaned from short-run (quarterly) supply studies. Short-run supply variations are commonly attributed to housing inventory adjustments by residential building suppliers, i.e., Grebler and Maisel (1963), Huang (1973), Hayashi and Trapani (1978).

Notwithstanding this, a number of short-run UK studies (Whitehead (1971); Hadjimatheou (1976); Mayes (1979)) have ignored inventory considerations and estimated equations similar to Equation (3). These studies have been criticised by Tompkinson (1979) for their *ad hoc* specification. Both Hayashi and Trapani and Tompkinson develop a more rigorous micro-theoretic framework, in which builders seek to maximise profits or minimise losses per period of time and which incorporates inventory considerations. In both cases, however, the derived supply equations require a breakdown of sold

6. Martin (1978) cites many of these studies.

and unsold housing inventory and site cost data in order to be estimated. Data constraints, therefore, militate against the use of either approach in an Irish housing model. An alternative approach initiated by Huang (1973) and developed by Mc Donough (1975) avoids *ad hoc* specification yet permits the resultant equations to be estimated on Irish data. They suggest, that due to resource shortages and inflexible production procedures, builders adjust their inventories ( $I_t$ ) to desired levels ( $I_t^*$ ) via a stock adjustment process, i.e.,

$$\Delta I_t = c(I_t^* - I_{t-1}) \quad (4)$$

Importantly, Mc Donough defines the change in inventories over a given period as the difference between house starts ( $HS_t$ ) and completions ( $HC_t$ ) in the same period, i.e.,

$$\Delta I_t \equiv HS_t - HC_t \quad (5)$$

substituting (5) into (4) gives,

$$HS_t = cI_t^* - cI_{t-1} + HC_t \quad (6)$$

The housing inventory series necessary to estimate Equation (6) is derived as follows:

$$HC_t = \sum_{i=0}^N w_i HS_{t-i} \quad (\text{where } \sum_{i=0}^N w_i = 1) \quad (7)$$

The expression,  $(1 - \sum_{j=0}^i w_j) HS_{t-i}$ , represents the number of uncompleted houses started in period  $t-i$ . Summing over all construction periods,  $N$ , gives the total number of uncompleted house or housing inventories, i.e.,

$$I_t \equiv \sum_{i=0}^N [1 - \sum_{j=0}^i w_j] HS_{t-i} \quad (8)$$

Since the lag weights ( $w_j$ ) have to be estimated from the completions, Equation (7), the inventory series is, of course, an estimate rather than the true underlying series. Moreover, by definition, it treats all completed houses as sold and no longer part of builders' inventories and it fails to distinguish between sold and unsold incompleated houses. None the less, due to data limitations it represents the best available approximation of the correctly-defined series. The optimal inventory equation derived by Hayashi and Trapani is

$$I_t^* = d_0 + d_1 S_t^c + d_2 C_t + d_3 R_t \quad (9)$$

where  $S_t^e$  = expected house sales,  $C_t$  = average maintenance costs per period for an unsold house and  $R_t$  = average profit per house during the period. Substituting Equations (8) and (9) into (6) yields an estimating equation for house starts,

$$HS_t = cd_0 + cd_1 S_t^e + cd_2 C_t + cd_3 R_t - c \sum_{i=0}^N [1 - \sum_{j=0}^i w_j] HS_{t-1-i} + HC_t \quad (10)$$

The house sales variable in Equation (10) has generally been approximated in UK studies by assuming "mortgages . . . are some constant proportion of total sales in a period" Tomkinson (1979, p. 204). As noted above, builders' profits are represented as the difference between house prices, labour, material and financial costs (proxied by the Bank Rate). Land or site costs are generally excluded due to lack of data.

House completion equations, such as Equation (7), have been rationalised by Mayes (1979, p. 22) on the basis that "the number of completions should be closely related to the number of starts with a distributed lag". The resultant specification, however, implies that the average construction period from start to completion does not alter over time and is independent of economic influences. It thereby fails to accord with Duffy's (1975, p. 125) finding that "construction periods will follow a path which is inversely related to the general cycle of housing demand". Attempts to incorporate these influences have generally resulted in modified equations of the following type:

$$HC_t = w(L) HS_t + g(X) \quad (11)$$

where  $w(L)$  is a polynomial in the lag operator,  $L$ , and  $X$  is a vector of cyclical economic variables. While this specification is an improvement on earlier efforts, it has been criticised by Ericsson (1977) and Borooah (1978) since it implies "a change in one of the economic variables will effect not merely current completions but also completions in every subsequent quarter, which, with a given level of starts, seems implausible" Borooah (1978, p. 32). An alternative 'variable' lag coefficient approach, originally due to Tinsley (1967) and modified by Ericsson, is developed by Borooah. The lag coefficients on past housing starts,  $w_i$ , are, themselves, made dependent on the values of the various cyclical economic variables. The resultant estimating form of the completions equation is, however, complex and difficult to estimate. Borooah does not provide any estimation results. A simpler variation of the approach, which draws on Duffy's findings, is possible. Instead of attempting to incorporate the full set of explanatory variables,  $X$ , into an explanation of the lag weights, some index,  $U_t$ , of the general cycle of housing demand may be used, i.e.,

$$w_i = h_i + k \left[ \frac{\sum_{N=0}^i U_{t-N}}{i+1} \right] \quad (12)$$

The lag weights,  $w_i$ , in Equation (12) depend on technological factors, the  $h_i$  coefficients, and the averaged value of the cyclical index,  $\left[ \frac{\sum_{N=0}^i U_{t-N}}{i+1} \right]$  since the relevant start commenced.

The interaction of supply and demand also constitutes an important modelling consideration. The durability of housing, the lengthy production process involved, the lengthy legal procedures and imperfect information facing potential house purchasers, together with the disequilibrium nature of the mortgage market on which they depend, all suggest that the market is non-clearing in the short run. Given the complexity of the market it is not surprising that Frömm (1973) and D'Amours and Nadeau (1974) have been critical of the extent to which disequilibrium considerations have been incorporated in national housing models. Both Whitehead (1974) and Mayes (1979) treat supply as predetermined in the short run and estimate the demand equation in the form of a price equation rather than a quantity equation. It appears more reasonable, however, to incorporate potential supply side influences and express *relative* house prices as a function of the excess flow demand for housing, i.e.,

$$(\text{PH}_t/\text{PO}_t) = f_1 (\Delta K^d - \Delta K^s) \quad (13)$$

where  $\text{PH}/\text{PO}$  is the price of houses relative to other goods, and  $\Delta K^d$  ( $\Delta K^s$ ) is the demand for (supply of) house additions. The disequilibrium nature of Equation (13) poses problems of estimation and identification of the structural coefficients. Two general approaches to overcome these problems have been suggested by Fair and Jaffee (1972, p. 497):

One general approach to this problem is to try to separate the sample into demand and supply regimes such that each schedule may be appropriately fitted against the observed quantity for the sample points within its regime. Another approach is to try to adjust the observed quantity for the effects of rationing and then fit both schedules over the entire sample period using the adjusted quantity.

A simpler version of the first approach is to assume the observed quantity is supply determined throughout the sample period, i.e.,

$$\Delta K_t^s = \Delta K_t = \text{HC}_t \quad (14)$$

This preserves the disequilibrium nature of the model and the assumption is reasonable, given the dependence of current completions on past (pre-determined) housing starts.

### III THE MODEL

A model of the private house market is outlined beneath:

$$K_t^* = a_0 + a_1(PH_t/PO_t) + a_2 Y_t + a_3 HF_t + a_4 CCH_t + a_5 KLA_t \quad (1')$$

$$\Delta K_t^* = b_0(K_t^* - K_{t-1}) + b_1 MA_t \quad (2')$$

$$K_t \equiv K_{t-1} + HC_t + SLA_t \quad (3')$$

$$HC_t = w_0 HS_t + w_1 HS_{t-1} + w_2 HS_{t-2} + \dots + w_N HS_{t-N} \quad (4')$$

$$w_i = c_i + d \sum_{N=0}^i U_{t-N}/i+1 \quad (5')$$

$$HS_t \equiv \Delta I_t + HC_t \quad (6')$$

$$\Delta I_t = e(I_t^* - I_{t-1}) \quad (7')$$

$$I_t^* = f_0 + f_1 PH_t + f_2 W_t + f_3 CM_t + f_4 F_t + f_5 S_t \quad (8')$$

$$\Delta(PH_t/PO_t) = g[\Delta K_t^* - \Delta K_t] \quad (9')$$

Hypothesised Signs:  $a_2, a_3, b_1, w_i, c_i, d, f_1, f_5 > 0$

$a_1, a_4, a_5, f_2, f_3, f_4 < 0$

$0 \leq b_0, e, g \leq 1$

where:

CCH = Cost of housing capital

CM = Cost of raw materials

F = Financial costs

HC = House completions

HS = House starts

HF = Household formation

I\* = Desired stock of housing inventories

I = Actual stock of housing inventories

K\* = Desired stock of private houses

K = Actual stock of private houses

KLA = Stock of Local Authority houses

MA = Mortgage availability

PH = Price of houses



PO	=	Price of other goods
S	=	House sales
SLA	=	Sales of Local Authority houses
U	=	Cyclical construction indicator
W	=	Wage costs
Y	=	Real income.

Equation (1') describes the public's desired stock of private houses as a function of relative house prices, real income, household formation, the cost of housing capital and the stock of Local Authority houses. Equation (2') characterises the demand for private house additions as a partial adjustment of the start of period stock to its desired level. The adjustment process is additionally affected by the availability of mortgage finance.<sup>7</sup> Equation (3'), an identity, defines the current level of the private house stock as the previous periods' stock plus current completions and Local Authority sales. It, thereby, embodies the assumption that the supply of houses and the observed quantity are identical. Equation (4') describes the supply of house completions as a function of lagged house starts. Equation (5') treats the lag weights of Equation (4') as variable, dependent on both technological factors, the  $c_i$  coefficients, and economic factors, the average value of the cyclical indicator over the construction period. Equation (6'), an identity, adopts Mc Donough's definition of housing inventories: the previous periods' inventories plus current starts less current completions. Equation (7') characterises short run inventory changes by a stock adjustment process of inventories to their desired level. Equation (8') gives the determinants of desired inventories as house prices, material, labour and financial costs, which are intended to reflect the profitability of sales, and house sales, which are intended to reflect the demand for completions. Equation (9') suggests that relative house prices respond positively to the excess flow demand for houses and that the house market is non-clearing in the short run.

The model is broadly consistent with the thrust of theoretical developments in the literature, noted in Section II. The market is viewed as non-clearing, with mortgage availability constraining the demand for additions and economic factors constraining their supply. The determinants of house starts incorporate inventory considerations and the stock-flow relations which characterise the market are embodied in Equations (1') through (4'). These features mark points of departure from an earlier unpublished study

7. The adjustment mechanism in Equation (2') refers only to the demand side of the market and may be rationalised on the basis of adjustment costs or habit persistence (Gould (1968), Houthakker and Taylor (1970)). If mortgage availability is measured by excess demand for mortgages then the specification is consistent with a constant house stock and constant relative prices in equilibrium.

of the Irish housing market by Nolan (1978).<sup>8</sup> Figure 1 provides, for clarification, a simplified flow diagram of the principal relationships in the model.

An example may serve to clarify the adjustment processes contained in the model. Starting from equilibrium, an increase in income, through its effect on the desired stock, increases the demand for house additions. The excess flow demand, thereby generated, increases house prices. This both moderates demand and induces additional house starts, through its effect on builders' desired inventories. The consequential flow of completions, by augmenting the existing housing stock, also moderates the excess demand for houses. These basic equilibrating mechanisms are protracted due to the stock-flow relations characterising both sides of the market and the starts-completion construction lags.

The model may be simplified to the following estimating form:

$$PH_t/PO_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 HF_t + \alpha_3 CCH_t + \alpha_4 KLA_t + \alpha_5 K_{t-1} + \alpha_6 MA_t + \alpha_7 \Delta K_t + \alpha_8 PH_{t-1}/PO_{t-1} \quad (I)$$

$$HC_t = c_0 HS_t + c_1 HS_{t-1} + c_2 HS_{t-2} + c_3 HS_{t-3} + \dots + c_N HS_{t-N} + d \sum_{i=0}^N \left[ \sum_{N=0}^i U_{t-N}/i+1 \right] HS_{t-i} \quad (II)$$

$$HS_t = \beta_0 + \beta_1 PH_t + \beta_2 W_t + \beta_3 CM_t + \beta_4 F_t + \beta_5 S_t + \beta_6 I_{t-1} + HC_t \quad (III)$$

$$K_t \equiv K_{t-1} + HC_t + SLA_t \quad (IV)$$

$$w_i \equiv c_i + d \left[ \sum_{N=0}^i U_{t-N}/i+1 \right] \quad (V)$$

$$I_{t-1} \equiv \sum_{i=0}^N \left[ 1 - \sum_{j=0}^i w_j \right] HS_{t-1-i} \quad (VI)$$

$$d, c_1, \alpha_1, \alpha_2, \alpha_6, \alpha_8, \beta_1, \beta_5 > 0$$

$$\alpha_3, \alpha_4, \alpha_5, \alpha_7, \beta_2, \beta_3, \beta_4, \beta_6 < 0$$

$$\text{where: } \alpha_0 = a_0 z;$$

$$\alpha_1 = a_2 z;$$

$$\alpha_2 = a_3 z;$$

$$\alpha_3 = a_4 z;$$

$$\alpha_4 = a_5 z;$$

$$\alpha_5 = -z = - \frac{gb_0}{(1-gb_0a_1)};$$

$$\alpha_6 = b_1 z/b_0;$$

$$\alpha_7 = -z/b_0;$$

$$\alpha_8 = z/gb_0;$$

8. A fuller critique of Nolan's study is provided by McCarthy (1981). The unsatisfactory nature of his results suggested that a comparison with our own findings would prove unfruitful.

$$\begin{aligned}
 \beta_0 &= e f_0; & \beta_4 &= e f_4; \\
 \beta_1 &= e f_1; & \beta_5 &= e f_5; \\
 \beta_2 &= e f_2; & \beta_6 &= -e. \\
 \beta_3 &= e f_3;
 \end{aligned}$$

The estimating form of the model consists of six equations: three behavioural equations ((I), (II) and (III)) and three identities ((IV), (V) and (VI)). Equation (I) is obtained by substituting Equations (1') and (2') of the structural model into Equation (9') and solving for  $PH_t/PO_t$ . The equation is identified and implies the following solutions for the structural coefficients:

$$\begin{aligned}
 a_0 &= -\alpha_0/\alpha_5; & a_1 &= (1-\alpha_8)/\alpha_5; & a_2 &= -\alpha_1/\alpha_5; & a_3 &= -\alpha_2/\alpha_5; \\
 a_4 &= -\alpha_3/\alpha_5; & a_5 &= -\alpha_4/\alpha_5; & b_0 &= \alpha_5/\alpha_7; & b_1 &= -\alpha_6/\alpha_7; & g &= -\alpha_7/\alpha_8.
 \end{aligned}$$

Equation (II) is derived by substituting Equation (5') of the structural model into Equation (4') and collecting the multiplicative variables. The variable coefficients in Equation (II) are identical to those of Equation (5') of the structural model and may be used in conjunction with Equation (V) to obtain the lags weights,  $w_i$ . These in turn are inserted into Equation (VI) to derive the housing inventory series,  $I_t$ , required to estimate Equation (III). Equation (III) was obtained by substituting Equations (8') and (7') of the structural model into Equation (6'). The equation is identified and the structural parameters may be retrieved as follows:

$$\begin{aligned}
 f_i &= -\beta_i/\beta_6 \quad \text{where } i = 0, \dots, 5. \\
 e &= -\beta_6.
 \end{aligned}$$

The estimating form of the model, therefore, permits all of the structural parameters of the theoretical model to be recovered.

#### IV EMPIRICAL RESULTS

The model, which is simultaneous, was estimated on quarterly data by Two Stage Least Squares (TSLS). Where appropriate, the equations were corrected for autocorrelation using Generalised Least Squares (GLS) procedures. These involved first or second order moving average (MAV) or autoregressive (AUTO) error schemes. The estimation period extended from 1969(4) to 1976(3) and was dictated by the availability of the house starts series, which commenced in 1967(2) and ceased in 1976(4).

The estimated equations differ from those derived in Section III in the

following respects only. The real income and household formation variables, in Equation (I), are replaced by *per capita* income,  $\bar{Y}$ , to reduce multicollinearity. The house starts equation, Equation (III), is augmented by the inclusion of two dummy variables, for the following reasons. The house starts series is based on grant allocations by the Department of the Environment. It depends, therefore, not only on the number of house starts but also on grant eligibility conditions and the timing of applications. The timing of applications was advanced in 1973(1), in anticipation of the certificate of reasonable value (CRV) eligibility requirement, which was imposed in 1973(2). The first dummy, D1, is intended to account for the consequential increase in the measured house starts series in 1973(1) and has a positive sign *a priori*. Grant eligibility was restricted from 1976 onwards to applicants who were eligible for supplementary Local Authority grants. The second dummy, D2, is intended to account for the reduced coverage of the grant scheme from that date, and the consequential reduction in the measured house series. Its *a priori* sign is negative.

The estimation results are reported in Table 1. The Appendix provides a full listing of the model variables and sources. Graphs 1 to 4 chart the dynamic model simulations for house prices, the private house stock, house completions and house starts, against the actual history of these variables. These are intended to provide a quality check on the estimation results.

Equation (I) exhibits a high explanatory power and good tracking performance. All the coefficient estimates are correctly signed. The statistical insignificance of the coefficient of the change in the private house stock variable suggests that demand side factors dominate house price movements, at least in the short run, with supply side factors playing a subsidiary role. Of the various demand side influences both the cost and availability of mortgage credit predominate. *Per capita* real income exerts a sizeably positive but statistically insignificant effect on house prices. This finding, which is relatively invariant with respect to the income measure adopted,<sup>9</sup> may result from collinearity between the income and mortgage availability variables.<sup>10</sup> Subject to this reservation, we may conclude that mortgage credit conditions dominate the income-related component of private house demand, at least in the short run. The reduced form estimates imply the following structural equations:

$$K_t^* = 2,231,668 - 10,920 (PH_t/CPI_t) + 1,232,507 \bar{Y}_t - 6,023 CCH_t - 12.5 KLA_t \quad (1'^*)$$

9. Various distributed lags of the income measure adopted – the Central Bank's Quarterly GNP series – were attempted.

10. We are grateful to an anonymous referee for drawing this point to our attention.

Table 1: Estimation results 1969(4)-1976(3)

Equation number	(I)	(II)	(III)	
Fit Stats.	$\bar{R}^2$	.96	.77	.72
	F	100.4	33.8	10.071
	DW	2.08	2.03	1.93
	h	.25		
Track Stats.	RMSE	143.6	594.1	612.5
	RMSPE	1.88	15.7	20.9
	MAPE	1.65	13.5	14.2
GLS Stats.	Auto 1	Auto 2		
	Mav 1	Mav 2	.83   .16	.28   -.13
Equation	Dependent Variable	PH/CPI	HC	HS
		+51.61380 (2.18934)	.014 $\hat{HS}$ (.31234)	143.059PH/ $\hat{CPI}$ (1.67)
		+28.5 $\bar{Y}$ (1.068)	+ .062 HS(-1) (2.4)	+ 5.701 W (.123)
		- .1393 CCH (3.045)	+ .099 HS(-2) (5.6)	- .868 CM (.064)
		- .00029089 KLA (1.95266)	+ .13 HS(-3) (6.18)	- 36.8228 F (.33977)
	Independent Variables	- .0000231279 K(-1) (2.00865)	+ .144 HS(-4) (5.73)	+ .912 S (2.24)
		+ .00111 MA (2.79332)	+ .152 HS(-5) (5.55)	- .31689 I(-1) (4.08)
		- .000138918 $\hat{\Delta}K$ (.78435)	+ .149 HS(-6) (5.56)	+ 1 $\hat{HC}$ -
		+ .74744 PH(-1)/CPI(-1) (7.40809)	+ .136 HS(-7) (5.23)	+6832.84 D1 (7.107)
			+ .113 HS(-8) (3.73)	-2033.4 D2 (3.316)
		+ .079 HS(-9) (1.82)	-2088.5 (.545)	
		+ .036 HS(-10) (.551)		
		- .001 $\sum_{i=0}^{10} \left[ \frac{\sum_{n=0}^i U_{t-n}}{i+1} \right] HS_{t-i}$ (1.44)		

Estimation Technique: Two stage least squares. A hat over a variable indicates that it is an endogenous regressor and has been replaced in the estimation process by its fitted values.  
(t statistics in parentheses.)

RMSE = Root mean square error; RMSPE = Root mean square percentage error; MAPE = Mean absolute percentage error.

$$\Delta K_t^* = .166485 (K_t^* - K_{t-1}) + 7.99 MA_t \quad (2'^*)$$

$$\Delta(PH_t/CPI_t) = .0001858 (\Delta K_t^* - \Delta K_t) \quad (9'^*)$$

The coefficient on the Local Authority housing stock, KLA, is implausibly high. It implies that each additional Local Authority house reduces the demand for private houses by twelve houses. The stock demand elasticities calculated at sample means from Equation (1'\*) are:

$$E_{K^*, (PH/CPI)} = .989; E_{K^*, \bar{Y}} = .351;$$

$$E_{K^*, CCH} = .055 \text{ and } E_{K^*, KLA} = 2.67.$$

These imply that the desired stock of private houses is inelastic with respect to relative house prices, *per capita* income and the cost of borrowing and elastic with respect to the public housing stock. The public housing stock elasticity is implausibly high. The income elasticity is of similar magnitude to estimates reported by Whitehead (1974) — in the .01 to .05 range — and Hadjimatheou (1976) — .263. It is less, however, than broadly comparable estimates reported by Whitehead (1971) and Mayes (1979). It is important to note that estimates relate to the desired stock (number) of houses and not to the actual flow of house-related expenditures. Therefore, these are not directly comparable with expenditure-based estimates.<sup>11</sup> The cost of housing capital elasticity estimate is also similar in magnitude to estimates reported by Hadjimatheou (1976) and Whitehead (1971), but substantially less than Whitehead (1974). A detailed comparison with previous studies is, however, unlikely to prove fruitful, given the variety of models and variable definitions employed. Moreover, the real mortgage rate, which is adopted in this study, is a crude measure of the cost of housing capital. Thus, while our findings suggest that the several policies aimed at reducing the cost of housing capital have been misplaced, corroborating evidence, preferably with a carefully constructed cost of housing capital series, is required before this conclusion can be accepted with confidence.

The structural estimates for Equation (2'\*) suggest that, *ceteris paribus*, approximately 17 per cent of the shortfall between the desired and actual house stock will be reflected in the demand for house additions in each quarter. Mortgage availability was proxied by the number of mortgage approvals for new houses, made by the main lending agencies. The coefficient of this variable, in Equation (2'\*), while correctly signed, is excessively large.

11. Leser (1964) and Pratschke (1969), using Household Budget data, report income elasticities (relating to housing expenditure) in the neighbourhood of unity for Ireland. These estimates are broadly similar to comparable US findings.

Experimentation with absolute and relative credit rationing variables,<sup>12</sup> however, proved unfruitful.

The price adjustment coefficient in Equation (9'\*) permits the change in house prices, corresponding to any particular excess flow demand magnitude, to be calculated. For example, setting the CPI equal to its sample mean value of 153.53 implies that an excess flow demand for 10,000 houses would increase house prices by £285.

In the simulation of house prices (Equation (I), Graph 1) the historical values of  $K_{t-1}$  and  $\Delta K_t$  are replaced by the output from Equation (IV), in which the actual completions series is replaced by the calculated series. The historical values of the lagged price variable are also replaced, apart from the initial value, by the calculated series from Equation (I). The quality of the simulation performance (Graph 1) is quite good. The mean absolute percentage error (MAPE) is 1.65 per cent. The largest individual percentage error is 3.6 per cent and this is reflected in a relatively low root mean square percentage error (RMSPE) of 1.88 per cent.

The lag coefficients of Equation (II), the house completions equation, were estimated using a second order Almon lag scheme. Relative house prices reflect the conditions of excess demand or supply in the market (see Equation (9')) and hence appear the most suitable general indicator of housing activity,  $U$ . The lag structure in Equation (II), however, extends back over ten periods and, hence, relative house prices had to be ruled out due to insufficient observations. The construction industry unemployment rate was chosen instead. It is a contracyclical indicator and hence its expected sign is negative. It is also a less satisfactory measure than relative house prices. It is generally regarded as an imprecise measure of construction activity, (Hadjimatheou 1976, pp. 21-22) and for Ireland may partly reflect conditions external to domestic construction activity (see Walsh, 1974 and Geary and Jones, 1975).

The estimation results for Equation (II) are satisfactory in terms of goodness of fit and parameter determination. The corrected  $R^2$  is .77 and the "technical" lag coefficients,  $c_i$ , are all correctly signed and display a satisfactory pattern of significance. The shape of the lag structure is plausible and implies a mean "technical" lag from starts to completions of 5.2 quarters. The coefficient on the multiplicative variable is correctly signed but only weakly significant. This may reflect the quality of the indicator chosen.

The coefficient estimates for Equation (II) may be inserted into Equation (V) to obtain the variable lag weights,  $w_i$ . Taking mean sample values for

12. These were defined, respectively, as the number of unapproved mortgage applications and the ratio of unapproved applications to total applications in the hands of the main lending agencies.

$\sum_{N=0}^i U_{t-N}/i+1$  yields the following lag weights:

$w_0 = -0.0024821$	$w_6 = 0.1340658$
$w_1 = 0.0456507$	$w_7 = 0.1212721$
$w_2 = 0.0836395$	$w_8 = 0.0982994$
$w_3 = 0.1114666$	$w_9 = 0.0651554$
$w_4 = 0.12915$	$w_{10} = 0.0218376$
$w_5 = 0.13669$	$\sum_{i=0}^{10} w_t = 0.944745$

The mean sample lag weight estimates take on their expected shape and the sum of weights is close to its expected value of unity. The negative value for  $w_0$  is, however, incorrect.

In simulating the completions equation (Equation (II)) the historical values for house starts were replaced, as soon as was possible, by the calculated series from Equation (III). After the first ten quarters of the sample period all the historical values were replaced by the calculated series. The simulation performance, Graph 2, is disappointing. The equation tracks the trend movements in the actual completions series but fails badly to capture the cyclical variations. The MAPE and RMSPE are 13.5 per cent and 15.7 per cent, respectively. Further experimentation with the completions equation revealed a trade-off between fit and parameter determination, on the one hand, and simulation performance, on the other. An example is provided by the following equation:

$$\begin{aligned}
 HC_t = & -20.39 + .231 HS_{t-3} + 0.46 HS_{t-4} + .203 HS_{t-5} \\
 & \quad (2.64) \quad (0.53) \quad (2.41) \\
 & + .202 HS_{t-6} + .28 HS_{t-7} \\
 & \quad (2.36) \quad (3.29)
 \end{aligned}$$

It displays poorer overall determination. Its corrected  $R^2$  is .71. The implied lag shape is implausible, the sum of lag weights well exceeds unity and the pattern of coefficient significance is disturbing. None the less, its simulation performance, given in Graph 5, is more creditable than Equation (II). These findings suggest that there is scope for improving both the choice of cyclical indicator,  $U$ , and the specification of the variable lag weights.

The stock of private houses was simulated by inserting the output of the completions equation into Equation (IV). The historical values for the lagged private house stock were also replaced, apart from the first observation, by the calculated series from Equation (IV). The dynamic simulation performance, which is represented in Graph 3, is quite good and has an RMSPE of 0.52 per cent.



The inventory series,  $I_{t-1}$ , for Equation (III) was derived from Equation (VI), using the estimated variable lag weights  $w_i$  of Equation (V).<sup>13</sup> The coefficient on the completions variable, HC, was restricted to unity in estimating Equation (III). The estimated equation displays a satisfactory fit, with a corrected  $R^2$  of .72, and a good tracking performance, as illustrated in Graph 4. The cost variables in Equation (III), however, perform poorly. The wage variable coefficient switched sign when estimated by TSLS and is statistically insignificant. The coefficients on the materials and financial cost variables, while correctly signed, are also statistically insignificant. The poor performance of the cost variables may partly reflect the quality of the operation definitions used. The remaining variables are correctly signed and, with the exception of the relative house price variable, significant. The relative house price variable is significant at the 10 per cent confidence level. The coefficients on the two dummy variables are correctly signed and significant. The results suggest that expected house sales, relative house prices and inventory considerations dominate the house starts decision. The reduced-form estimates for Equation (III) permit the remaining equations of the structural model to be derived.

$$HS_t = \Delta I_t^* + HC_t \quad (6'^*)$$

$$\Delta I_t = .31689 (I_t - I_{t-1}) \quad (7'^*)$$

$$I_t^* = -6590.7 + 451.4 (PH_t/CPI_t) + 17.9W_t - 2.7CM_t - 116.2F_t \\ + 2.8S_t \text{ (+ dummy variables)} \quad (8'^*)$$

Equation (7'\*) implies that builders adjust their inventories to eliminate over 30 per cent of the discrepancy between the desired and start of period inventories in each quarter. The structural estimates for Equation (8'\*) must be interpreted with caution, in view of the quality of parameter determination of some of the reduced form estimates. Using Equations (6'\*), (7'\*) and (8'\*), the elasticities of house starts, evaluated at sample means, with respect to relative house prices, sales, the cost of material and financial (interest rate) costs are +1.6, +.712, -.05 and -.078, respectively. McDonough (1975), Hadjimatheou (1976) and Mayes (1979) all report inelastic elasticity estimates with respect to interest costs; McDonagh also reports an inelastic estimate with respect to materials costs. The magnitudes of the reported estimates in these studies are, however, in all cases, larger than those quoted above.

In simulating Equation (III) the historical values for the variables  $PH_t$ ,

13. The mean sample lag weights were used for ease of computation (variations in the actual weights are too small to appreciably affect the resultant inventory series).

$I_t$  and  $HC_t$  were replaced by the calculated series from Equations (I), (VI) and (II), respectively. The simulated series tracks the high variability in the actual house starts series reasonably well (Graph 4). The MAPE and RMSPE are 14.2 per cent and 20.9 per cent respectively.

## V CONCLUSIONS

The theoretical model set out in this paper represents a compromise between theoretical advances in housing literature and the limits set by data availability. It incorporates some key features, such as the stock-flow nature of the market, the complex demand and supply side response lags and the disequilibrium state of both the housing market and the mortgage market on which it depends. The data series used to estimate the model are deficient in many respects. The new house price series relates only to houses financed by the main lending agencies. The house starts and completions series are based on grant allocations and final payments respectively, by the Department of the Environment and are, therefore, imprecise. The derived inventory series is an estimate based on the starts and completions data of houses under construction, whereas the appropriate measure is housing inventories available for sale. While all of these factors limit the precision which can be claimed for the model estimates, the most important deficiency, in our view, is the absence of a comprehensively defined cost of housing capital series. This both hinders a proper evaluation of government housing policies and limits the scope for distinguishing between the consumption and asset components of housing demand. Given the variety of available housing policy alternatives, the construction of such a series, to gauge their efficiency and distributional effects, is likely to prove rewarding.

Despite the data limitations and the complexity of the market, the model both fits and tracks (with the exception of house completions) the data fairly well. The disequilibrium nature of the market and lengthy construction lag complicate the calculation of long-run elasticities and policy multipliers. None the less, the general pattern of market response to policy changes may be inferred directly from the structural estimates. The current quarter impacts, for instance, of a 1 per cent mortgage subsidy is to increase the desired house stock by 6,000, the demand for house additions by 1,000, relative house prices by .18, desired housing inventories by 85 and house starts by 27. The principle repercussive effect in subsequent quarters is the dissipation of house demand by the rise in relative house prices. The relative price rise moderates the stock demand for houses by 2,000 in the second quarter. Accordingly, the second quarter effect, for each of the variables, is approximately two-thirds of the magnitude of the first quarter effect. This pattern is relayed into subsequent quarters, complicated only by the com-

pletion of the policy induced house starts. This supply side response is, however, both weak and sluggish. If we abstract from its effect on the adjustment mechanism and take the effect on house starts in each quarter as two-thirds of the previous quarters' effect and further assume that each start is ultimately completed then the long run supply response to the mortgage subsidy is approximately 80 additional house completions. The foregoing estimates, while tentative, suggest that policies of this type are primarily inflationary and distributional in their consequences and affect output and employment only weakly. The example also highlights scope for improvements in the model. Policy induced changes in the housing market also have repercussive effects in the mortgage market and, ideally, mortgage availability should be endogenised to take account of these effects. Moreover, the model should, if possible, be modified to analyse policies which discriminate between the new and second-hand house market. Other areas for improvement involve adjusting the house stock series for quality changes, incorporating expectations mechanisms more fully, and disaggregating the model to account for different regional responses. The model employed in this study draws attention to informational requirements necessary to undertake these improvements and may provide some insights into the functioning of a complex market.

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## APPENDIX

<i>Variable</i>	<i>Definition</i>	<i>Source</i>
CCH	Cost of housing capital. Proxied by $(MR - PH)$ where MR = mortgage rate and PH = annualised rate of house price inflation	CB and QBHS
CM	Index of the price of materials used in the construction industry	ISB
CPI	Consumer Price Index	ISB
D1	CRV dummy variable taking a value of 1 in 1973(1), otherwise 0.	DLGR 1972/3, 1973/4 1974, p. 46.
D2	Grant restriction dummy taking a value of unity for the 1976 quarters, otherwise 0.	DLGR 1976, p. 37.
F	Financial costs borne by builders. Proxied by the Central Bank rediscount rate.	CB
HS	Number of private house starts	QBHS (1)
HC	Number of private house completions	QBHS (1, 2)
K	Stock of private houses. 1971(2) taken as the 1971 census figure. Subsequent figures derived by adding private completions plus Local Authority sales to the 1971(2) figure; earlier figures derived by reverse procedure	Census and QBHS

KLA	Stock of Local Authority dwellings 1971(2) taken as the 1971 Census figure. Subsequent observations derived by adding Local Authority completions less Local Authority sales to 1971(2) figure; earlier observations by reverse procedure	Census and QBHS
MA	Mortgage availability proxied by the number of new house loan approvals by the main lending agencies	QBHS
MR	Mortgage rate	CB
PH	The average gross price of new houses for which loans were approved by the main lending agencies	QBHS
POP	Quarterly population statistics interpolated from the annual series derived by Whelan and Keogh (1980) based on electoral register	
S	Private house sales proxied by MA	QBHS
SLA	Sales of Local Authority houses. Quarterly interpolations of annual series published by McKeon and Jennings (1978)	
U	Percentage unemployment rate in the general building (houses etc.)	ISB
W	Hourly earnings of skilled workers in the construction industry. Figures derived from Quarterly Inquiry into the Building and Construction industry	ISB
Y	Estimated quarterly GNP series at constant prices	CB (3)

$\bar{Y}$  = *per capita* real income. Defined as  $Y / POP$ .

*Abbreviations:*

CB	= <i>Central Bank Quarterly Bulletin</i>
DLGR	= <i>Department of Local Government Annual Report</i>
ISB	= <i>Irish Statistical Bulletin</i>
QBHS	= <i>Quarterly Bulletin of Housing Statistics</i>

*Notes:*

1. House starts and completions series based on grant allocations and grant payments, respectively, by the Department of Local Government and hence affected by the timing of applications and payments.

2. NESc (1977), estimated an average delay of about 4 months between completions and grant payments. The QBHS series was, accordingly, shifted back one quarter.
3. Kindly provided by the Economic Affairs Department of the Central Bank.

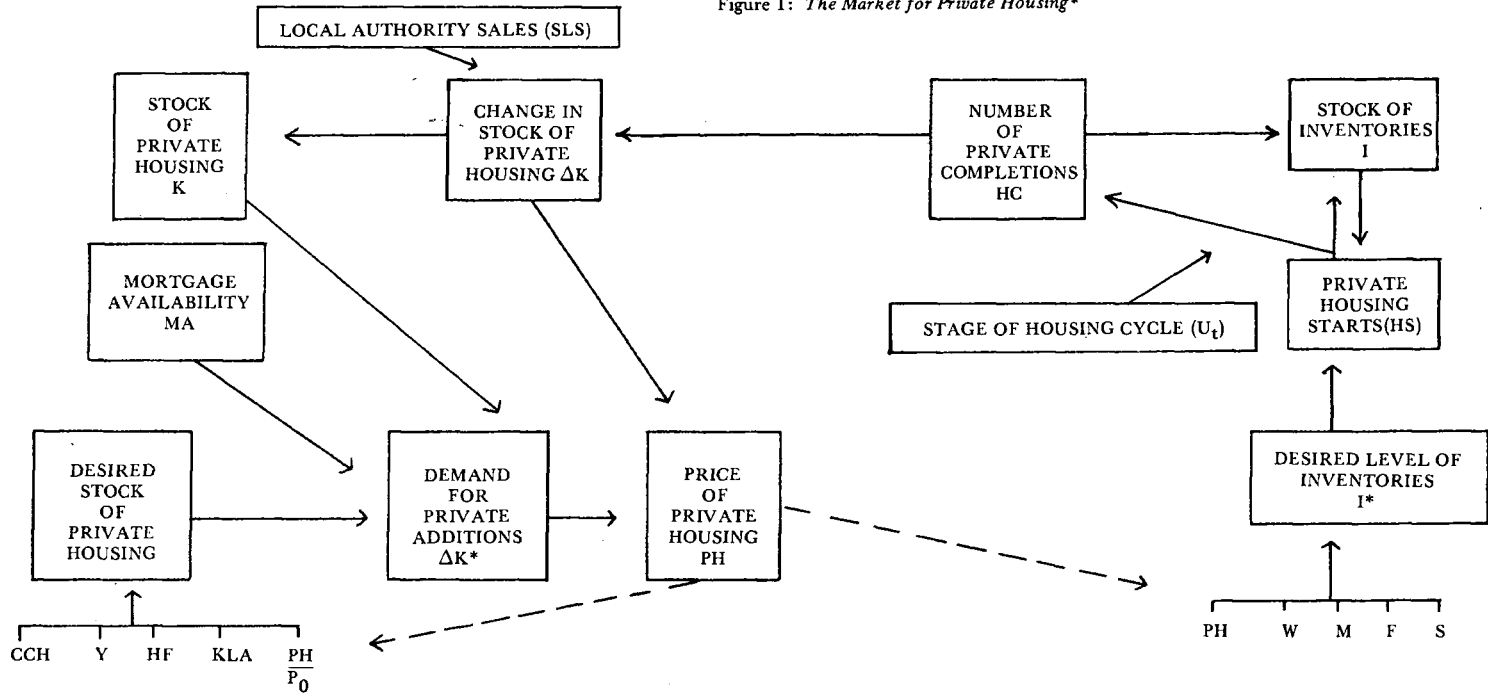
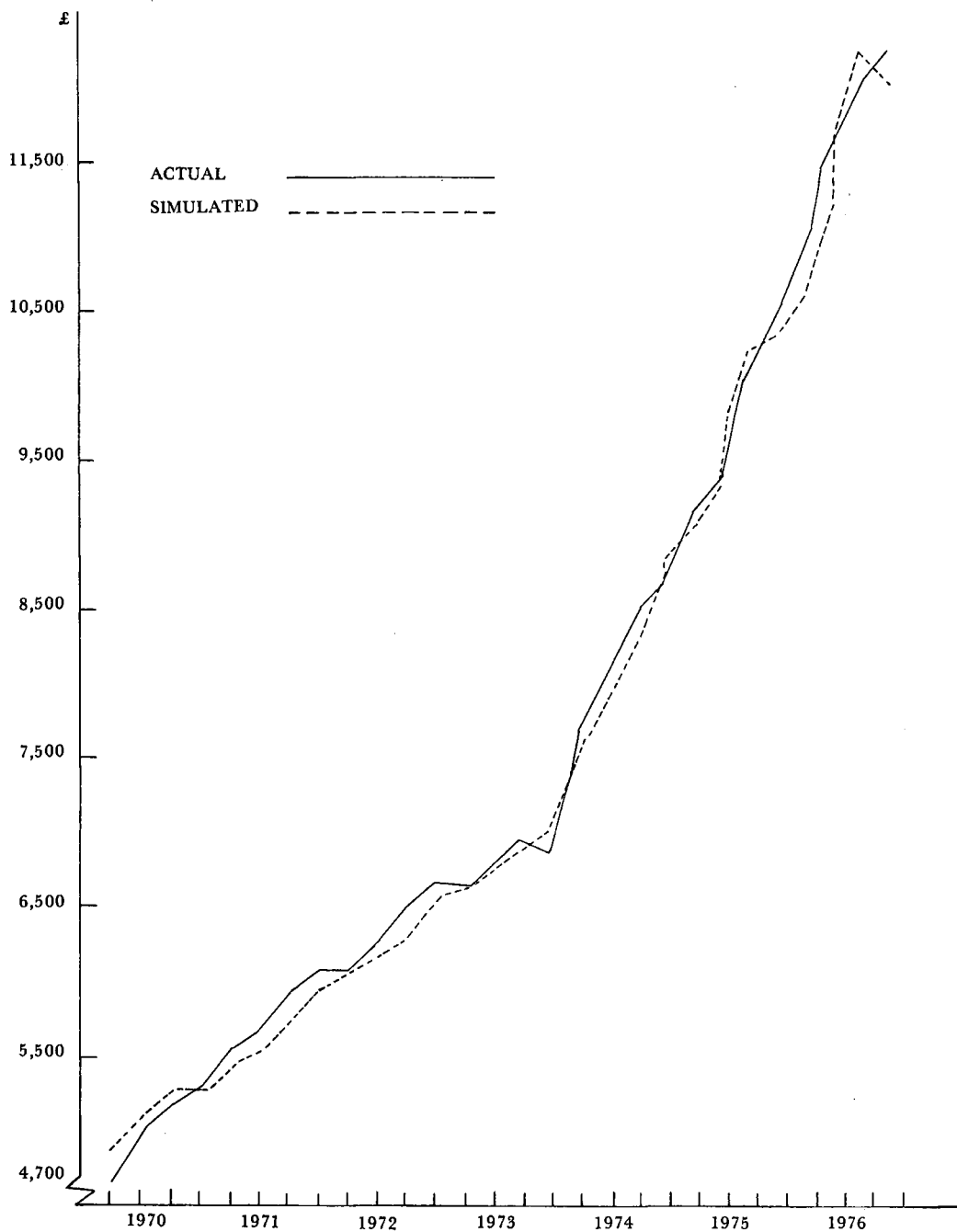


Figure 1: The Market for Private Housing\*

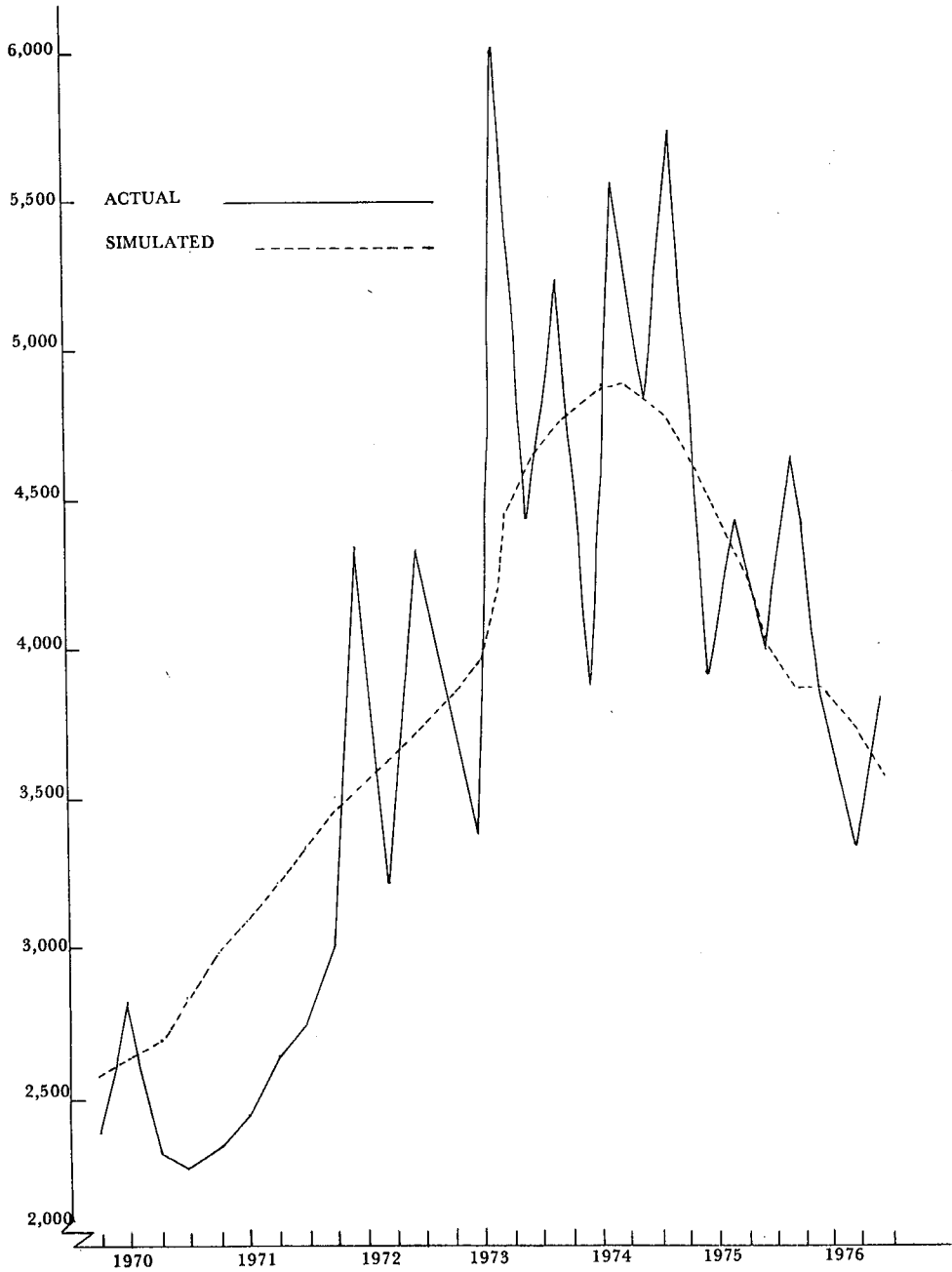
Solid Arrowheads indicate direction of causality.  
 \*(Initial Stock of Private Houses & Builders inventories omitted for simplicity of Representation).



Graph 1: *Actual and Simulated House Prices*

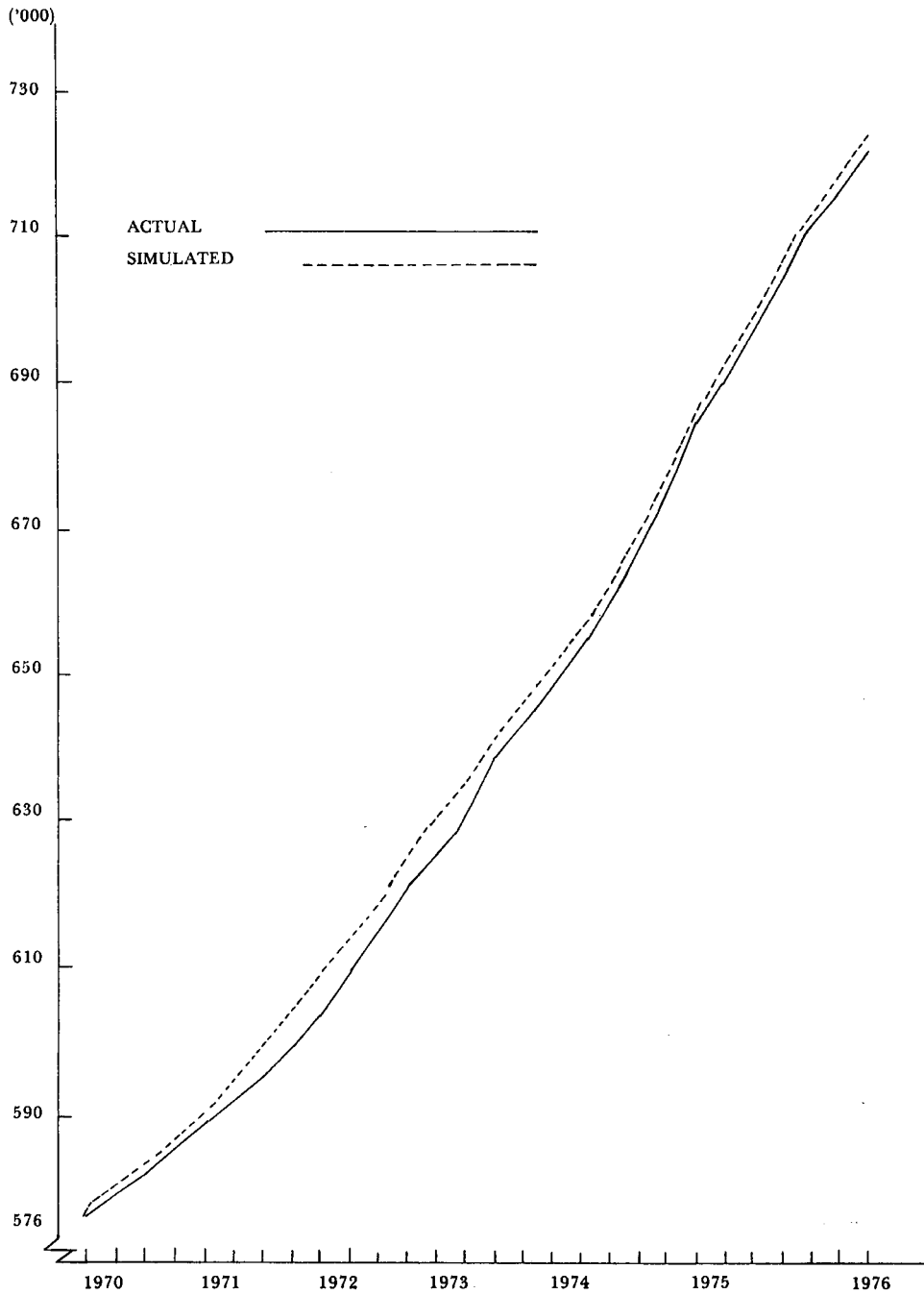


Time Bounds: 1969 Fourth Quarter to 1976 Third Quarter

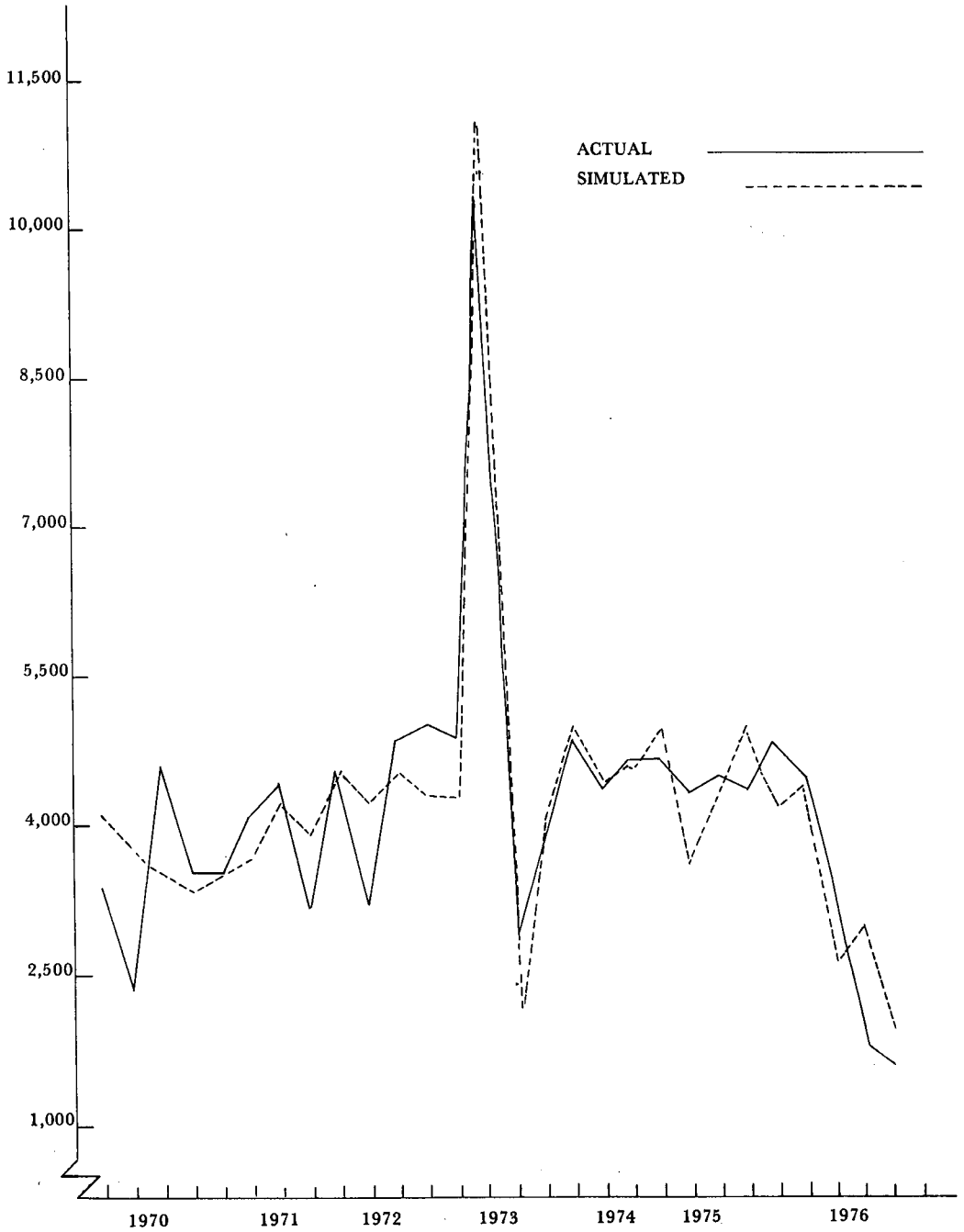
Graph 2: *Actual and Simulated Number of Completions*

Time Bounds: 1969 Fourth Quarter to 1976 Third Quarter

Graph 3: *Actual and Simulated Stock of Private Dwellings*



Time Bounds: 1969 Fourth Quarter to 1976 Third Quarter

Graph 4: *Actual and Simulated Number of Housing Starts*

Time Bounds: 1969 Fourth Quarter to 1976 Third Quarter

Graph 5: *Actual and Simulated Number of Completions*

