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Modelling Housing Investment for Seven Major OECD Countries

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by

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This paper presents new housing equation estimates for the major seven countries in INTERLINK, the OECD world econometric model. Theoretical and empirical aspects of housing investment behaviour are discussed in a model context. Estimation results using an adjustment model for the stock of houses are presented and discussed, together with simulations comparing the performances of the old and new housing blocks in the model. The results embody an important improvement in understanding the aggregate determination of aggregate residential investment.

* * * * *

Cet article présente de nouvelles estimations d'équations pour l'investissement en logements pour les sept plus grands pays de l'OCDE dans INTERLINK, le modèle économétrique mondial de l'OCDE. Les aspects théoriques et empiriques du comportement de l'investissement résidentiel sont discutés dans le contexte du modèle. L'estimation d'un modèle d'ajustement du stock de logements est présentée et discutée, ainsi que les simulations comparant les performances respectives des anciens et nouveaux blocs du modèle. Les résultats indiquent une nette amélioration dans la compréhension de la détermination de l'investissement résidentiel aggrégé.

No. 63: MODELLING HOUSING INVESTMENT FOR SEVEN MAJOR OECD COUNTRIES

by

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Thomas Egebo is currently on assignment in the OECD Econometric Unit of the Economics and Statistics Department as part of the OECD Young Professionals Program. Ian Lienert is an administrator in the Growth Studies Division of the Department. Special thanks go to Pete Richardson for many helpful suggestions. The authors would also like to thank David Reifschneider, whose initial work for the United States served as the starting point for the analysis reported in the Working Paper, and John Martin for useful comments on an earlier draft.

MODELLING HOUSING INVESTMENT FOR SEVEN MAJOR OECD COUNTRIES

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MODELLING HOUSING INVESTMENT FOR SEVEN MAJOR OECD COUNTRIES

INTRODUCTION

1. This paper describes an empirical study of housing investment in seven major OECD economies, which was carried out in the Economics and Statistics Department to provide both a better understanding of the determinants of residential investment and new estimates for the housing block for the OECD's world macroeconometric model INTERLINK (1).

Table 1

RESIDENTIAL CONSTRUCTION AS A PERCENTAGE OF GDP

	Average			
	1960-67	1968-73	1974-79	1980-86
United States	4.8	4.8	4.9	4.4
Japan	5.2	7.2	7.6	5.6
Germany	7.3	7.2	6.1	6.2
France	6.8	7.8	7.9	6.3
United Kingdom	3.5	4.0	4.1	3.5
Italy	7.6	7.4	6.7	6.4
Canada	5.2	5.8	6.7	5.5
Total of above countries	5.3	5.7	5.9	5.1

Source: OECD, Economic Outlook Historical Statistics 1960 - 1986, Paris 1988.

2. Residential construction is a relatively small component of domestic expenditure and, as a share of national income, has declined in a number of countries during the 1980s (see Table 1). Housing's economic importance is, however, disproportional to its GDP share, largely because it tends to be one of the most cyclical components of aggregate demand. In the United States, for example, the average peak-to-trough decline in housing construction since the 1950s has been 45 per cent, compared with declines of 10-15 per cent in industrial production and less than 10 per cent in overall output. Housing

starts are also quite commonly used as a leading indicator of changes in macroeconomic activity (see for example OECD, 1987).

3. The timing and amplitude of housing cycles are commonly associated with a number of specific features of the housing market. These include:

-- the stock/flow dynamics of house purchase decisions, arising from the durability of housing and its role as an investment good; and

-- the sensitivity of housing supply and demand to financial market conditions, in particular the variability of the supply and price of credit over the cycle and the roles of interest rates and credit controls as instruments of monetary policy.

4. The durability of housing (2) and its role as a capital good, makes the distinctions between the investment flow, the physical stock of dwellings and the associated flow of housing services of major significance. Whereas durability relates to the physical structures, which depreciate over time, housing services are produced both from basic factor inputs contributing to the housing stock (labour, capital and materials) and other inputs, such as light and heating (3). Thus the markets for housing stocks and housing services can be expected to behave differently.

5. As a durable investment good, the demand for housing can also be split according to tenure choice, between owner occupancy and renting (4). House owners act as both consumers of housing services and investors in a durable asset, with the joint consumption/investment choice of owner occupation being affected by a variety of short- and long-term considerations. These include house and land prices (5), operating costs, depreciation, mortgage interest rates, tax rates and expected capital gains (6). The dynamics of house purchases are also affected by past household saving rates (since a down payment from personal savings is usually required prior to purchase) and expectations of future income (to meet mortgage repayment commitments) (7).

6. The specific heterogeneity of housing gives rise to information costs and a wide variety of search and transactions costs (brokers' fees, legal costs, stamp duties, moving costs) make it expensive for households to adjust the quantity of housing services consumed. Renovation and maintenance in housing expenditures is a significant part of new residential construction (8). Finally, heterogeneity makes the distinction between the markets for new and existing dwellings important.

7. In many countries, institutional arrangements for the provision of finance for house purchase have from time to time tended to constrain the supply of mortgage credit, with the mortgage interest rate not clearing the market. In a number of countries, however, financial deregulation during the 1980s has been accompanied by a more competitive environment for housing finance, so that mortgage interest rates are more closely determined by financial market conditions and thereby the conduct of monetary and fiscal policies. In addition to their influence on credit conditions, governments exert direct influences on housing markets, through tax concessions on mortgage interest payments, the subsidisation of construction, and the control of rent and land prices. Housing development is also restricted by building codes and zoning laws (9) and government-owned dwellings constitute an important part of the housing stock in many OECD countries (10).

8. The list of special factors influencing housing is potentially long and very much beyond the scope of the present empirical study (11). In Section I, which follows, a broad theoretical framework is described within which the key determinants of aggregate investment in housing may be analysed empirically. This necessarily involves the exclusion of a number of specific factors, in particular heterogeneity and the explicit influence of governments in the housing market. Within this general framework, Section II examines the determinants of housing identified in a range of empirical studies for the largest OECD countries.

9. In common with many of the models surveyed, the housing equations contained in earlier versions of the OECD INTERLINK model have been specified and estimated in terms of residential investment flows, as opposed to stocks. Section III discusses these previous equations, and then presents estimation results for the seven major OECD countries based on a revised stock-adjustment specification. The implications of these revisions for overall model properties are analysed in the context of a set of standardised INTERLINK simulations and some general conclusions are presented in the final section.

I. A FRAMEWORK FOR MODELLING HOUSING

10. Assuming service flows to be proportional to the stock, equation [1] below can be used to represent a demand function for housing services:

$$K(t) = \alpha * R(t) + X(t) \qquad [1]$$

where K(t) denotes the net stock of dwellings at time t, R(t) the implicit rental price per unit of dwelling stock, the so-called "user cost of housing". α is the slope of the demand curve with respect to the user cost, and X(t) a vector of exogenous determinants of the demand for housing services. The latter might include, for instance, real per capita income, demographic variables (the rate of family formation, the age distribution, etc.) and operating and maintenance expenditures.

11. With respect to the supply of new housing units, let P(t) represent the price per unit and C(I(t), Y(t)) the cost function of a representative builder producing I(t) gross additions to the housing stock in time t. Y(t) is a vector of cost determinants (the price of materials and labour, supply conditions of scarce inputs and the costs of borrowing to construction firms). Assuming construction output decisions to be based on marginal cost pricing, a linear approximation of the marginal cost condition implies a supply function of the following form:

$$I(t) = \beta * P(t) - Y(t) \qquad [2]$$

where $\beta>0$ is the slope of the supply curve with respect to prices.

12. By definition, the flow of new residential investment is equal to the change in the stock of dwellings plus the amount of stock scrapped or depreciated:

$$I(t) = \Delta K(t) + \delta K(t-1) \qquad [3]$$

where δ is the rate of decay (scrapping and depreciation) and Δ denotes the first difference operator.

13. The model is closed through an equation relating stock and flow prices, by assuming that the imputed flow price of a unit of housing is equal to the amortised stock price, thus:

$$R(t) = [r + \delta - \dot{P}^e(t)]*P(t) \qquad [4]$$

where r is the rate of interest and $\dot{P}^e(t)$ the expected capital gain.

Substituting equation [4] into equation [1] yields:

$$K(t) = \alpha*(r + \delta - \dot{P}^e(t))*P(t) + X(t) \qquad [5]$$

Combining equations [2] and [3] also gives:

$$\Delta K(t) + \delta K(t-1) = \beta P(t) - Y(t) \qquad [6]$$

14. Thus, for given values of the initial stock of houses, K(0), and a boundary condition for future interest costs, equations [5] and [6] can be solved simultaneously to give general expressions for the time paths of housing stocks and market-clearing prices which converge to steady-state solutions, as functions of expectations and exogenous demand and supply determinants. In such a generalised system, the derived equilibrium trajectories of K(t) and P(t) will depend upon both exogenous supply and demand factors, the rate of interest and decay, thus:

$$K(t) = g(X(t), Y(t), \delta, r) \qquad [7]$$

$$P(t) = h(X(t), Y(t), \delta, r) \qquad [8]$$

15. Most analysts of housing sector behaviour have adapted this framework in various ways -- notably with respect to the inclusion of individual supply- and demand-side elements, the modelling of flows of investment as opposed to the stock of houses, the treatment of the formation of price and explicit assumptions with respect to the functional forms of equations. A number of these issues are examined in more detail in the following section.

II. EMPIRICAL APPROACHES TO MODELLING OF HOUSING

16. The development of disaggregated and complex housing models is a natural outcome of the heterogeneity of dwellings and the interplay between the housing market, the financial sector and government intervention. Such models are often designed to describe a metropolitan housing market, either independently or as part of models analysing urban housing policies and urban development (12). However, large empirical models of the housing sector have also been developed (13). Detailed housing models are useful for analysing the effects of specific public housing programs, but they are in general too extensive and complex to fit into macroeconomic models such as INTERLINK, which are largely concerned with the development of the main economic aggregates.

17. This section reviews some of the alternative approaches adopted in aggregate models of the housing sector and recent empirical evidence on the influence of key explanatory variables. Central features of the models examined are summarised in Appendix A. A further investigation of the role of financial variables in empirical housing equations can be found in Chouraqui et al . (1988), who review a number of macroeconometric models. In the latter context, a wide diversity of approaches and empirical results is found to exist.

A. Aggregate housing models

1. General modelling considerations

18. Given housing's special characteristics, Stahl (1985) argues that there seems to be no universally acceptable concept of either housing market behaviour or an appropriate model for residential investment. Indeed, the empirical literature offers housing investment equations and aggregate housing models which, although designed to analyse rather similar questions, nevertheless employ a wide range of different specifications, simplifying assumptions and explanatory variables.

19. A fundamental choice for modellers is whether the stock of houses or the flow of new investment is to be modelled and how the underlying market process is assumed to influence aggregate dynamic behaviour. Consistent with the theoretical framework outlined earlier, studies of housing supply commonly model the flow of new construction (14). When housing demand is analysed, there is a corresponding -- though less pronounced -- tendency to use a stock approach or to take the existing stock of houses directly into consideration. Nonetheless, flow equations, where stock considerations are excluded altogether, are very common.

20. Most aggregate studies of housing focus on one side of the market and do not attempt to model the simultaneous influence of demand and supply on the dwelling stock and house prices, as in equations [7] and [8] (15). Exclusion of the supply side is usually based explicitly or implicitly on the assumption that the supply of houses in the long run adapts to demand in a perfectly elastic manner. In the short run, prices are assumed to react so as to influence demand, with the supply of housing assumed to be price-inelastic (16). In contrast, the steady-state price of houses is commonly

assumed to be determined by construction costs, independently of the level of construction. In terms of the preceding theoretical framework, such models assume the long-run equilibrium stock, K(t), is determined by equations [1] and [4] alone, with the price, P(t), determined by unit costs only.

21. Many authors use the stock-adjustment model to describe the housing market -- in most cases without explicitly stating the assumptions underlying the market mechanism. Such models commonly specify the dynamics with a partial adjustment process, with the dwelling stock adjusting to long-run demand over a finite period. A flexible adjustment approach seems appropriate, given that demand for houses may react slowly to changes in underlying economic forces, and that supply adjusts slowly to anticipated changes in demand.

22. In the simple version of the stock-adjustment model, where the speed of adjustment is exogenous, equation [7] above is expressed as:

$$K(t) = ([f(X(t), p(c(t)), \delta, r)]/K(t-1))^{**\tau} \qquad 0 < \tau < 1 \qquad [9]$$

where f(X(t), p(c(t)), δ, r) represents the long-run demand for houses, τ measures the speed of adjustment and p(c(t)) the price of houses as a function of production costs. A further refinement of equation [9] is to model the adjustment parameter τ as a function of short-run factors, including supply-side pressures (17).

2. Specification of housing in macroeconometric models

23. Equations for residential investment in macroeconometric models use a wide variety of specifications, often with demand and supply determinants included together in the same hybrid equation.

24. An adjustment mechanism is frequently specified, either in terms of the stock of houses or in terms of the flow of new investment. Some models use a stock-adjustment approach, others include the dwelling stock in flow equations to proxy renovations and maintenance. Flow equations where stock variables have been entirely excluded are relatively common. Three out of four major models of the United Kingdom (the National Institute, H.M. Treasury, and London Business School models), use a flow approach without taking the stock of houses into consideration. The Bank of England model incorporates a stock/flow system, with stock demands and supplies affecting house prices, which in turn influence the flow supply of new investment. For France, on the other hand, housing equations in a number of the large macroeconometric models are based entirely on the stock-adjustment approach.

25. Differences across countries do not imply consensus within countries about the representation of housing markets in macroeconometric models. The Canadian models surveyed illustrate how specifications vary from model to model (18). In three models (RDX2, CANDIDE and FOCUS), housing starts are related directly to mortgage approvals. In TIM, housing investment is determined from the demand side only, while RDXF, MTFM and CEFM model housing starts through supply-side equations, with demand affecting the price of houses. Only in CHASE is the housing equation based upon a stock-adjustment mechanism, although the stock of houses is often used in the other models as a determinant of investment in renovations and maintenance.

26. The stock-adjustment model makes a distinction between net investment (additions to the stock) and gross investment (additions and maintenance). In the short run, investment is influenced by the desire to change the level of stocks; in long-run equilibrium, investment will be equal to the level of replacements necessary to maintain the optimal stock. Since the flow of new investment during a year is small compared to the initial stock, shifts in the long-run desired stock of houses can bring about rather large fluctuations in investment. In some macroeconometric models, these dynamic properties are approximated by adding accelerator terms to investment flow equations. Goux (1983), however, finds that in distinguishing between short- and long-term effects, the stock-adjustment specification appears theoretically superior to a flow-adjustment mechanism.

B. Variables included in equations of housing demand

27. Commonly, empirical studies and macroeconometric models focus only on the demand side of the housing market, reflecting the implicit assumption that the supply of dwellings is perfectly price-elastic in the long run. The range of factors assumed to influence demand are discussed below, with some reference to the empirical evidence of their importance presented in Appendix A. Numerical comparisons are however limited, as wide differences in the definitions of housing investment, stocks and the explanatory variables included make them hazardous. Further references can be found in Smith et al. (1988), and the surveys mentioned therein.

1. Demographic factors

28. Demographic factors constitute an important determinant of demand for housing, especially in the long run. Burch et al. (1986) identify the housing sector as being the most sensitive to changes in population trends. Hendershott (1987), for the United States, and Dicks (1988), for the United Kingdom, also suggest that demographic factors may have been the major source of changes in housing demand over the last few decades.

29. The number of households establishes the need for dwelling units. In turn, the number of households can be explained by the size of the population, its age distribution and age-specific headship rates (the ratio of households to population). Changes in headship rates may be influenced by changing marriage and divorce patterns, but most investigators find that economic explanations dominate. The growth in the number of households, expressed in terms of changes in the size and age distribution of the population at unchanged headship rates, can be thought of as the basic demographic factor driving long-term trends in housing demand (19). Such a measure gives only a partial explanation of changes in demand for the number of housing units and not the average real value of these units. Hendershott (1980) makes this distinction and estimates the number and average value of one- to four-family housing starts in two separate equations, with demographic factors influencing the number of starts and the average quality of starts depending upon economic factors.

30. To the extent that shifts in age-specific headship rates over time are themselves attributed to economic developments, such factors may also explain the pattern of headship and owner-occupancy rates across age groups. Haurin et al . (1987) find that increases in income and wealth over the life cycle explain a large part of the observed rise in ownership rates with age. It may

thus be difficult to establish how demographic trends at unchanged aggregate income will influence the real value of housing demand at the aggregate level.

31. Macroeconometric models using the stock approach generally take demographic factors into account by specifying the demand for housing stock in per capita terms, including income per capita as an explanatory variable. It is thereby assumed that the elasticity of housing stock with respect to the population is unity for unchanged per capita income. Unlike detailed housing models, such models do not explicitly consider how changes in the age distribution influence housing markets. Frequently, however, the population variable excludes some part of the population expected to exert only a minor influence upon housing demand.

2. Household income and wealth

32. Given that a dwelling is also an investment good, housing demand can be analysed using the portfolio balance sheet approach, as developed by Brainard and Tobin (1968). In such a model, asset demand is expressed as a function of both household wealth and the rates of return on assets and liabilities in the household balance sheet. De Rosa (1978) uses such a structure to model housing stock demand, but explicit wealth variables are not commonly included in empirical studies or in the housing sectors of macroeconometric models. This reflects both a lack of readily usable wealth series and, in the case of macroeconometric models, the complexity of modelling household wealth.

33. In contrast, real disposable household income is used as a key variable in most empirical models of housing demand. Real income often enters in a distributed lag form as a proxy for permanent income or wealth, but changes in income are also used to capture short-term cyclical swings in demand.

34. The majority of empirical models incorporating a permanent income term embody long-run elasticities with respect to real permanent household income or real permanent income per capita in the vicinity of unity, although some differences exist. A unitary elasticity is certainly desirable for long-run model properties, given that housing constitutes an important part of household sector expenditures.

3. House prices and inflation

35. Increases in house prices relative to those for other goods are generally expected to induce substitution away from houses, thereby lowering demand. Anticipated house price inflation, on the other hand, may increase the demand for dwellings as an investment good. Both of these channels of influence may be captured by measures of the user cost of housing, although the two effects are often separated by splitting the user cost into relative price and real interest rate terms.

36. Given the heterogeneity of dwellings, the correct measurement of unit prices poses an important problem. One approach is to estimate prices of dwelling characteristics (20) and use these to generate house price indices, but there may be some uncertainty as to the content and correctness of such measures. This can be seen as a reason for not including house price indices; a similar implication would flow from the argument that house prices in the long run reflect only construction costs. It is not uncommon for house price indices to be replaced by the more supply-orientated investment deflators, but

often housing market prices influence investment only through the inclusion of real, as opposed to nominal, interest rates.

37. There are important differences of opinion concerning the overall effects of inflation upon housing demand. Poterba (1984), for example, argues that because interest payments are normally tax-deductible and capital gains normally not taxed, inflation reduces the effective cost of homeownership, independently of real interest rates. In support of this view, he presents evidence that higher inflation substantially raises housing investment. Kearl (1979), examining the so-called "tilt" problem, provides estimates which support the opposite view. The tilt problem arises because higher inflation and nominal mortgage interest rates increase the initial real burden of debt service for a mortgage with fixed nominal repayments. Only in the future does higher nominal income reduce the debt burden. If real interest rates are unchanged, the present value of total mortgage payments is not affected, and the tilt effect may only reduce demand for houses because of capital market imperfections.

38. A final consideration is that individuals observing past price increases may increase their subjective uncertainty concerning future price developments. Rosen et al. (1984) provide evidence that price uncertainty substantially discourages people from becoming homeowners, to the extent that the user cost to risk-averse consumers also rises.

4. Financial variables, taxes and consumer confidence

39. Housing investment is generally acknowledged as one of the most interest-rate-sensitive demand components in macroeconometric models (21).

40. A variety of interest rates have been used in empirical studies. Normally, long-term rates are thought to influence the demand side, given the long-term perspective of the house purchase decision. These are often measured by either the mortgage rate, as the cost variable, or by long-term bond rates, acting as indicators of the returns to alternative assets. Models of housing supply, on the other hand, tend to include short-term interest rates, reflecting the borrowing costs for home builders.

41. There seems to be a general tendency towards lower steady state real interest rate/user cost elasticities when these are obtained in the context of stock, as opposed to flow, model specifications. It can be argued that this finding largely reflects the difference in stock versus flow dynamics. Changes in real interest rates may affect the flow of new investment more in the short run, as the stock of houses adjusts to a new optimum, than in the long run. For example, in the stock-adjustment equation of the U.S. Federal Reserve MPS model, the elasticity of housing expenditure with respect to the cost of capital is -1.3 in the short run compared with -0.7 in the long run. Goux (1983) constrains the optimal stock of houses to depend upon population and income only, but allows the user cost of capital to influence the speed of adjustment towards long-run equilibrium.

42. Although the availability of mortgage credit is often considered to be an important determinant of housing investment, the analysis of credit rationing is troublesome because of the lack of theory as to why mortgage rates fail to clear the market for housing credit. Goodwin (1986), using multimarket disequilibrium econometrics, concludes that non-price credit rationing in the mortgage market has had profound short-term spillover effects

on demand and supply in the U.S. housing market. Arcelus and Meltzer (1973) find a negative correlation between credit availability and housing investment. They explain this in terms of the stock of mortgages being the reciprocal of the value of owner's equity in a given stock of houses. They conclude that there is no causal relationship independent of the mortgage interest rate, a conclusion also supported by de Rosa (1978).

43. The empirical evidence for the inclusion of credit rationing variables is mixed. The Canadian models RDX2, CANDIDE and FOCUS adopt an extreme approach, with housing starts determined by mortgage approvals. Other models include credit rationing variables alongside traditional explanations such as population, permanent income and real rates of interest, but many consider only the price of credit and not the amount. Explicit inclusion of credit variables or non-price terms related to mortgage availability may also require the addition of complicated structures in the model, to secure reliable simulation properties. The cost of such complications often outweigh the potential gains, especially if credit squeezes are infrequent or of relatively short duration.

44. Many detailed studies and some macroeconomic models correct for the influence of taxes when calculating user costs, but quite often the implicit cost of housing services is proxied by some real pre-tax interest rate. Tax rate effects are commonly excluded because of difficulties in analysing the specific channels of influence of complex tax systems. Measurement problems are also a major deterrent.

45. A further variable often found in empirical work on housing demand is the rate of unemployment. The underlying rationale here is that changes in unemployment capture "consumer confidence" or "uncertainty" effects, and are therefore expected to influence the demand for houses negatively in the short run. When included, the short-run effects of changes in unemployment rates are quite often estimated to be both significant and substantial.

C. Summary of empirical findings

46. Given the complexities of housing markets, it is hardly surprising that studies of aggregate housing have used a wide range of different models. Some broad findings nevertheless stand out from the above survey of the empirical literature.

47. In the context of the general theoretical framework outlined in Section I, modellers commonly assume that the supply of dwellings adjusts fully to demand in the long run and that abnormal profits exist only in the short run, when the supply of new units is rigid. In models where medium-term properties rather than short-term fluctuations are emphasized, the dynamics of supply-side rigidities are often included in a relatively simplified fashion and the main emphasis is directed towards modelling the demand side of housing.

48. Demographic trends and household income are found to be important determinants of the demand for houses, and the long-run elasticity with respect to real permanent income *per capita* is in general estimated as being close to unity. Furthermore, most studies find that the demand for dwellings is sensitive to developments in the financial sector, reflected in significant real interest-rate terms and, less commonly, in the inclusion of flows of

mortgage credit. However, there are considerable variations across models as to the quantitative importance of financial variables.

III. HOUSING EQUATIONS IN THE MAJOR SEVEN COUNTRY MODELS OF INTERLINK

49. The OECD INTERLINK model is a representation of the world economy which combines a set of small to medium-sized semi-annual macroeconometric models, one for each OECD Member country, with reduced-form trade and balance of payments relationships for six non-OECD country groupings. The model and its associated data systems serve as important tools in the OECD's macroeconomic work, notably in the construction of short- and medium-term projections and the analysis of macroeconomic policies.

50. To preserve the manageability of a multi-purpose world model, its various parts are required to embody a certain degree of standardisation across countries. On the one hand, behavioural equations need to represent theoretically plausible behaviour without incorporating too many ad-hoc country-specific elements. At the same time, this needs to be achieved without the use of complex structures or introducing unnecessary variables into the model. With the model being used increasingly for medium-term applications, it is crucial that equations also incorporate well-defined equilibrium properties.

A. Previous housing investment equations in INTERLINK

51. The previous set of equations for residential investment in INTERLINK have not met the above aims particularly well. Over the recent past, different specifications have been employed with significant variations between countries in variables included and parameter values estimated. The former housing investment equations included in the major seven country models are summarised in Table 2. These used a flexible accelerator approach for Japan and the United Kingdom, while the other country models all employed a simple logarithmic flow-adjustment model. These flow equations were mainly demand-oriented, with real disposable household income and real long-term interest rates used as the principal determinants. No attempt was made to take demographic factors into account.

52. With these equations, the steady-state elasticities of housing investment with respect to real disposable income varied substantially across countries, from 0.4 in the U.S. model to 5.4 in the French model. Similarly, the semi-elasticities with respect to the real rate of interest ranged from -0.6 in Germany to -3.7 in Canada. For Japan, a significant real interest rate term could not be estimated. Instead, financial influences were represented by the growth in money velocity and the steepness of the yield curve. The former was intended to proxy for credit rationing, while a steepening of the yield curve was used to proxy the effects of a greater availability of long-term loanable funds. Although the yield curve argument has some intuitive appeal, the simulated effects of a rise in long-term

Table 2

PREVIOUS HOUSING INVESTMENT FLOW EQUATIONS IN INTERLINK

	UNITED STATES	JAPAN[1]	GERMANY	FRANCE	UNITED KINGDOM[1]	ITALY	CANADA
Type of equation	partial adjustment	flexible accelerator	partial adjustment	partial adjustment	flexible accelerator	partial adjustment	partial adjustment
Steady-state elasticities or semi-elasticities with respect to:							
Real disposable household income	0.4	1.0	2.0	5.4	1.0	2.4	0.7
Real long-term interest rate	-2.8		-0.6[2]	-3.4	-2.1	-2.3	-3.7[2]
Yield curve[3]	8.1	5.3					
Growth in money velocity		-2.7					
Real price of housing investment[4]					-1.0		
Real compensation per employee[4]			-1.3	-5.6		-2.2	

1. Elasticities are calculated using mean values of the ratio of investment to disposable income.

2. The squared real interest rate enters the equation. The reported semi-elasticities are calculated assuming the real interest rate rises from 2.5 to 3.5 percentage points.

3. The difference between the long-term bond rate and short-term interest rate.

4. Measured in relation to the overall consumer price deflator.

interest rates at unchanged short rates were counter-intuitive in the cases of Japan and the United States, as the estimated yield curve term had a larger coefficient than that of the real rate of interest. In addition, overall prediction performance was in general poor out-of-sample and, taken together, the empirical results were not considered to be particularly robust.

B. Specifying a stock-adjustment equation for housing

53. In the present study, the actual stock of houses, KHV, is assumed to adjust gradually towards a desired stock, KHV*. In equation [9] of Section I, a simple first-order adjustment model was considered, but to allow for a richer dynamic structure, a second-order adjustment process of the following form is employed:

$$(KHV(t)/KHV(t-1)) = [(KHV^*(t)/KHV(t-1))^{**\tau_1}]*[(KHV(t-1)/KHV(t-2))]^{**\tau_2} \quad [10]$$

where τ_1 and τ_2 are adjustment parameters.

54. A comparison between the first and alternative second-order adjustment models is given in Figure 1, assuming a first period adjustment rate of 5 per cent. A range of alternative second-order terms is used to illustrate the sensitivity of the adjustment path to changes in this parameter. Whereas the simple first-order adjustment model portrays the adjustment to changes in the desired housing stock as gradually declining through time, a positive second-order term allows for a "reaction period", with the largest adjustments taking place some time after the initial shock. For values of τ_2 less than zero, cycles in the adjustment process appear, whereas positive values of τ_2 close to unity imply some overshooting.

55. Given equation [10], semi-annual values of residential investment, expressed at annual levels, IHV, are linked to the net stock of dwellings, KHV, through the identity:

$$KHV(t) = IHV(t)/2 + KHV(t-1)*(1-RSCRH(t)/200) \quad [11]$$

where RSCRH represents the annualised rate of decay (scrapping and depreciation) of the net housing capital stock.

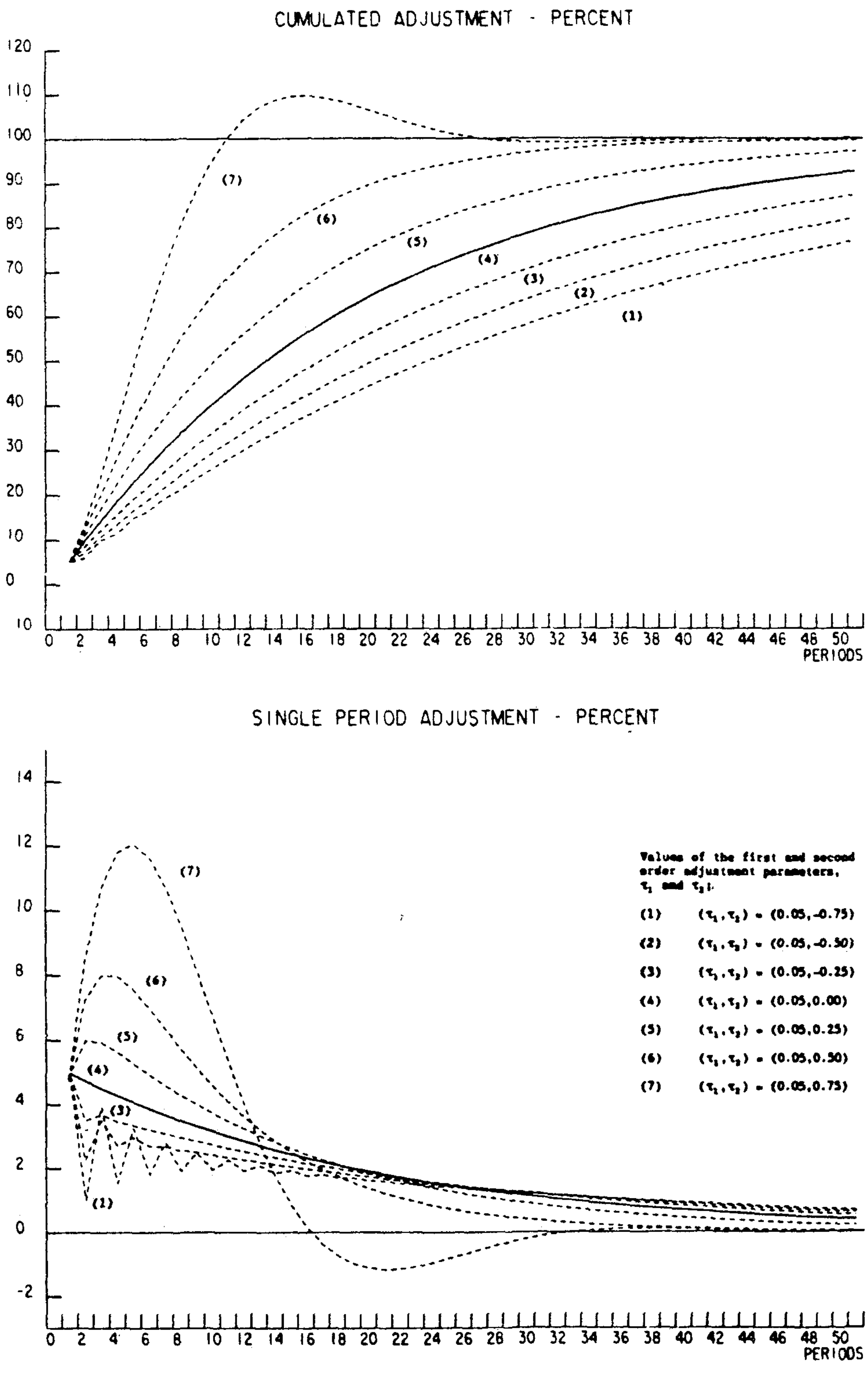
56. To capture the effects of demographic trends on housing demand, the desired stock of houses is specified <u>per capita</u> of the working age population, POPT (22). <u>Per capita</u> demand for dwelling stock is in turn linked to real permanent income <u>per capita</u>, which ensures a unit elasticity of housing demand with respect to population for unchanged income <u>per capita</u>.

57. The link between housing and the financial sector is modelled by including the expected real long-term interest rate as a determinant of the desired dwelling stock <u>per capita</u>. Both the mortgage rate, IRM, which affects the costs of borrowing for house purchases, and a "typical" long-term interest rate, IRL, representing an indicator of returns to alternative assets, were considered in estimation. Depending on the nature of the financial sector in each country, the mortgage rate may be closely related to long-term rates

Figure 1

RESPONSES OF A SECOND-ORDER DYNAMIC ADJUSTMENT PROCESS

Model: $KHV/KHV(-1) = (KHV^*/KHV(-1))^{**\tau 1} * (KHV(-1)/KHV(-2))^{**\tau 2}$



charged elsewhere in the financial system. Hence, estimates including either IRM or IRL may differ only slightly. In allowing for expected capital gains from increases in house prices, changes in both the price of new investment and the price of privately consumed housing services have been examined as proxies for future capital gains in the market.

58. No attempt is made to model credit rationing explicitly. First, the existing empirical evidence as to the importance of credit rationing is inconclusive. Secondly, since INTERLINK does not model the flow of financial resources between sectors in any detail, mortgage credit flows cannot be easily endogenised. Finally, although credit rationing variables may be helpful to explain past fluctuations in housing investment, it is probably inappropriate to maintain these for projections in a more deregulated environment. For the United States and the United Kingdom, however, dummy variables were found to be necessary to capture the effects of recognised historical credit crunches.

59. The specification of the desired stock of per capita houses, KHV*/POPT, finally includes both the real price of new investment, as a proxy for trends in the relative price of houses, and the ratio of the deflator for private consumption of housing services to the overall consumer price index. Whereas increases in the real price of new investment are expected to reduce demand for dwellings, the latter term can be expected to enter the equation with a positive sign, representing the real value of service flows from housing and thus the opportunity cost of not investing in a dwelling.

60. Taking logarithms, the equation for the desired stock of houses, per capita, is:

$$\begin{aligned} \ln(KHV^*(t)/POPT(t)) = \phi_0 &+ \phi_1 * \ln(M(YDRH(t)/POPT(t))) \\ &+ \phi_2 * (M(\langle IR(t)\rangle) - M(\dot{P}^e(t))) \\ &+ \phi_3 * \ln(M(PCPH(t)/PCP(t))) \\ &+ \phi_4 * \ln(M(PIH(t)/PCP(t))) \end{aligned} \qquad [12]$$

where real permanent income per capita is defined as a moving average of current real disposable household income divided by the working-age population, YDRH/POPT, with the formation of expectations simplified to a moving average function of current and past values. $M(\dot{P}^e)$ represents expected inflation in the housing market, PCP is the consumer price deflator, PCPH the deflator for private consumption of housing services, PIH the residential investment deflator and <IR> the long-term interest rate. M(z) represents a moving average process.

61. Adding to equation [10], short-term fluctuations in the rate of unemployment as a proxy for consumer confidence and inserting equation [12] gives the final estimation form:

$$\begin{aligned} \Delta\ln(KHV(t)) = \psi_0 &+ \psi_1 * \ln(M(YDRH(t)/POPT(t))) \\ &+ \psi_2 * (M(\langle IR(t)\rangle) - M(\dot{P}^e(t))) \\ &+ \psi_3 * \ln(M(PCPH(t)/PCP(t))) + \psi_4 * \ln(M(PIH(t)/PCP(t))) \\ &- \tau_1 * \ln(KHV(t-1)/POPT(t)) + \tau_2 * \ln(KHV(t-1)/KHV(t-2)) \\ &+ \nu_1 * \Delta UNR(t) \end{aligned} \qquad [13]$$

62. Given the broad framework of equation [13], estimates for each country were obtained, allowing for some flexibility in the inclusion of explanatory variables and in the specification of lags used to determine real permanent per capita income and the expectations of prices and real interest rates. In the case of housing stocks, it was possible to use unmodified stocks reported by national sources only for the United States and Japan. A major concern for the other countries examined was to establish data for dwelling stocks consistent with the national accounts definitions of housing investment used in INTERLINK, whilst at the same time using as much information as possible contained in available housing stock data found in national sources. Appendix B describes further the sources and methods used in generating the data for net stocks of houses, which enter as the dependent variable in equation [13].

C. Estimation results

1. A comparison across countries

63. Table 3 presents estimates of equation [13] for each of the major seven economies, selected from a range of wider results for inclusion in INTERLINK on the basis of goodness-of-fit and the plausibility of long-term properties. Consideration was also given to the costs of including unexplained dummies or introducing new variables. The corresponding long-run housing stock elasticities are summarised in Table 4.

64. Permanent income per capita is found to be highly significant in all seven cases and, contrary to the previous flow equations for housing in INTERLINK, the estimates show long-run income elasticities clustered around unity, with relatively little variance across countries. Only the estimate for the United Kingdom, at 1.4, seems to be somewhat of an outlier, although it does not contradict the empirical evidence referred to earlier (23).

65. Although correctly signed for all countries, there is more variability in the estimates of real interest rate sensitivity, with semi-elasticities ranging from 2.4 for Japan to just above unity for Canada, the United States and Germany, and less than 0.5 for France, Italy and the United Kingdom. Most striking, compared to the figures in the flow equations of Table 2, is the statistical significance of the real interest rate term for Japan. The estimates of short-run real interest rate effects are significant at the 99 per cent level for Japan, Canada and the United States and at the 95 per cent level for the United Kingdom and Italy. This term is statistically significant only at the 90 per cent level for France and at the 80 per cent level for Germany.

66. The cross-country average of long-run interest rate semi-elasticities is less than half that of the flow equations shown in Table 2, reflecting the dynamics of flows implicit in the stock-adjustment model. However, a small change in the desired housing stock may nevertheless have a substantial effect on investment in the short run, as the actual stock of dwellings adjusts towards its new equilibrium. Given the overall specification, the short-run semi-elasticity of investment flows with respect to the real rate of interest varies positively with the speed of adjustment and negatively with the ratio of investment to stocks. Calculations using sample-period averages show that for the United States, where the speed of adjustment is relatively high, the short-run real interest rate elasticity is more than four times the long-run value. For the United Kingdom -- the country with the slowest process of adjustment -- the short-run percentage change is twice that of the long run.

Table 3

PREFERRED STOCK-ADJUSTMENT EQUATIONS

$$\Delta.\ln(KHV) = \psi_0 + \psi_1 * \ln(M_h(YDRH/POPT)) + \psi_2 * (M_j(\langle IR\rangle) - M_k(\dot{P}^{*})) + \psi_3 * \ln(M_m(PCPH/PCP)) + \psi_4 * \ln(M_n(PIH/PCP)) - \tau_1 * \ln(KHV(-1)/POPT) + \tau_2 * \ln(KHV(-1)/KHV(-2)) + \nu_1 * \Delta.UNR$$

	UNITED STATES[1]	JAPAN	GERMANY	FRANCE	UNITED KINGDOM[2]	ITALY[3]	CANADA
ψ_0	0.3024 (8.01)	-0.1626 (0.71)	0.0458 (1.62)	0.0146 (0.42)	-0.1445 (3.93)	0.0019 (0.02)	0.0558 (1.50)
ψ_1	0 1187 (7.37) h=8	0.0949 (3.56) h=2	0.0232 (4.29) h=8	0.0514 (5 48) h=5	0.0639 (14.79) h=3	0.0316 (6.44) h=6	0.0583 (2.66) h=8
ψ_2	-0.00170 (4.95) j=2, k=10	-0.00206 (6.65) j=2, k=6	-0.00029 (1.45) j=2, k=10	-0.00021 (1.72) j=2, k=4	-0.00012 (2.63) j=2, k=3	-0.00010 (2.53) j=2, k=9	-0.00072 (4.32) j=2, k=6
ψ_3	0.0757 (7.44) m=4	0.0334 (2.82) m=2		0.0173 (3.45) m=4			0.0513 (4.24) m=2
ψ_4				-0.0218 (2.3) n=2	-0.0256 (5.38) n=1	-0.0135 (3.58) n=4	-0.0361 (2.31) n=3
τ_1	0.1446 (7.91)	0.0844 (5.56)	0.0251 (4.93)	0.0485 (5.88)	0.0454 (6.26)	0.0310 (3.21)	0.0602 (2.80)
τ_2	0.306 (4.41)	0.349 (3.77)	0.535 (7.36)	0.285 (2.36)		0.569 (8.89)	0.415 (3.36)
ν_1	-0.00079 (2.85)		-0.00120 (4.80)		-0.00135 (3.82)	-0.00086 (2.86)	-0.00104 (3.15)
Sample	65I - 86II	70II-86II	73II-86II	66II-86II	64I-86II	70I-86II	65I-86II
Estim. method	OLS	OLS	OLS	OLS	MINDIS[4]	OLS	OLS
SEE[5]	3.04	4.00	2.44	2.20	4.31	1.76	4.06
R^2-adj.	0.966	0.991	0.967	0.985	0.925	0.991	0.861
Durbin Watson	1.92	2.05	2.10	2.19	2.02	1.93	2.05
H-statistics	-0.01	-0.18	-0.30	-1.00		-0.09	-0.67
RHO_1	0.549 (3.55)						0.239 (1.65)
RHO_2	-0.184 (1.50)					-0.509 (4.17)	
Mean lag (semesters)	3.80	6.71	17.56	13.76	21.04	12.92	8.72
Median lag (semesters)	2.30	4.30	12.01	9.04	13.93	8.97	5.76
<IR>	IRM	IRL	IRL	IRL	IRL	IRL	IRL
<P>	PCPH	PCPH	PIH	PCPH	PIH	PCPH	PIH

1. A credit dummy (described in a footnote to the text) is included, with an estimated coefficient of -0.00319 (4.42)

2. Estimated with the credit variable described in the text (coefficient 0.358 (5.29)), and a dummy equal to 1 in 68II with coefficient 0.00378 (3.54).

3. Estimated with a dummy equal to 1 in 75I with coefficient 0.0020 (4.07).

4. Minimum distance non-linear estimation.

5. Percentage standard error of predicted investment.

Table 4

LONG-RUN HOUSING STOCK ELASTICITIES

	UNITED STATES	JAPAN	GERMANY	FRANCE	UNITED KINGDOM	ITALY	CANADA
Permanent income per capita, ϕ_1	0.82	1.12	0.93	1.06	1.41	1.02	0.97
Real rate of interest, ϕ_2 [1]	-1.18	-2.44	-1.17	-0.43	-0.25	-0.33	-1.19
Relative price of housing services, ϕ_3	0.52	0.40		0.36			0.85
Relative price of housing investment, ϕ_4				-0.45	-0.56	-0.44	-0.60

1. Long-run semi-elasticity

67. Only for the United States did it prove necessary to introduce the mortgage lending rate. For the other countries, long-term market rates were found to perform as well or, in some cases, better than mortgage rates. Besides reflecting the fact that the two interest rates are often highly correlated, this result may indicate the importance of returns to alternative assets.

68. Neither of the relative price effects is significant for Germany, whereas both terms enter the estimated equations significantly and correctly signed for France and Canada. In the estimates for the remaining four countries, only one relative price term is found to be significant in each case -- the relative price of housing services being preferred for the United States and Japan, and the relative price of housing investment being preferred in the equations for the United Kingdom and Italy. The estimated long-run price elasticities are centred around one-half. The observed variation in the significance of relative price terms across countries may reflect differences in methods of measuring the housing services deflator, PCPH, especially with respect to the treatment of imputed rent (24). The evidence concerning the most appropriate representation of expected inflation in the housing market is also mixed, but with the exception of Canada, the rate of change in the housing services deflator performs better than the rate of change in the investment deflator in countries where the relative price of services is significant (the United States, Japan and France).

69. The short-run changes in the unemployment rate enter the estimated equations correctly signed and with highly significant coefficients for all countries, except France and Japan. In the latter case, the rate of

unemployment may not be a particularly good indicator of household uncertainty, with its stability over economic cycles being a special feature of the Japanese labour market.

70. The different dynamic properties of the estimated equations are illustrated in Figure 2. As can be seen in Table 3, the second-order adjustment term, τ_2, is found to be positive and significant for all countries, except the United Kingdom, and the largest housing stock adjustments therefore lag significantly behind changes in the desired stock. This result is consistent with short-run supply-side rigidities, which have not been modelled explicitly, but nevertheless may be captured in the profile of the adjustment process. Some diversity is observed for the overall speeds of adjustment. Mean and median lags for the adjustment of actual to desired housing stock are relatively short for the non-European countries where full adjustment is accomplished fairly quickly, as can be seen in Figure 2. Much slower adjustment speeds are estimated for the four European economies (25). To the extent that these measures reveal something about the flexibility of housing markets and the adaptability of flows of financial resources to changes in the demand for new dwellings, the result might also shed some light on the diversity of long-run real interest rate responses. In this respect, it is interesting to note that with the exception of Germany the results suggest that the fastest-adjusting countries also display the most interest-rate-sensitive demand for dwellings.

71. The overall tracking performance measured in terms of the corresponding flows of housing investment for the stock estimates of Table 3 are shown in Figure 3. Given the simplicity of the estimated specifications, the estimates generally track the actual path of residential investment rather well, although there is some slight underestimation of peaks and troughs of a few short-run investment cycles. A notable exception is for the United States, where the cyclical movements in investment are larger and more regular than for other countries. For Japan, the United Kingdom, Italy, and in particular Germany, the estimated timing of troughs and peaks often differ from actual developments.

2. Results for individual countries

72. The following paragraphs summarise some of the main features of the estimation results by country, referring also to the wider range of estimates obtained.

73. For the **United States**, the estimated long-run income elasticity is, at 0.82, the lowest of the seven countries but is consistent with the empirical evidence presented in Section II. Slightly higher estimates (0.84-0.86) are found when the maximum lag on income is reduced, but the estimate appears to be quite robust to changes in specification.

74. The real interest rate term in the housing stock-adjustment equation includes the Federal Home Loan Banking Board series for the average mortgage interest rate on housing loans, which appears superior to alternative long-term rates. Until the mid- to late 1970s, interest rate ceilings and other institutional rigidities caused periodic outflows of deposits from savings and loans associations into other financial assets. Savings and loans associations, the largest source of mortgage credit, reacted by rationing mortgage credit through a variety of non-interest-rate methods (see Gabriel, 1987). Although this practice has disappeared, it was taken into account in

Figure 2

ESTIMATED DYNAMIC ADJUSTMENT OF THE HOUSING STOCK

Dynamic responses to a change in the desired stock of houses, KHV*, occuring in semester one

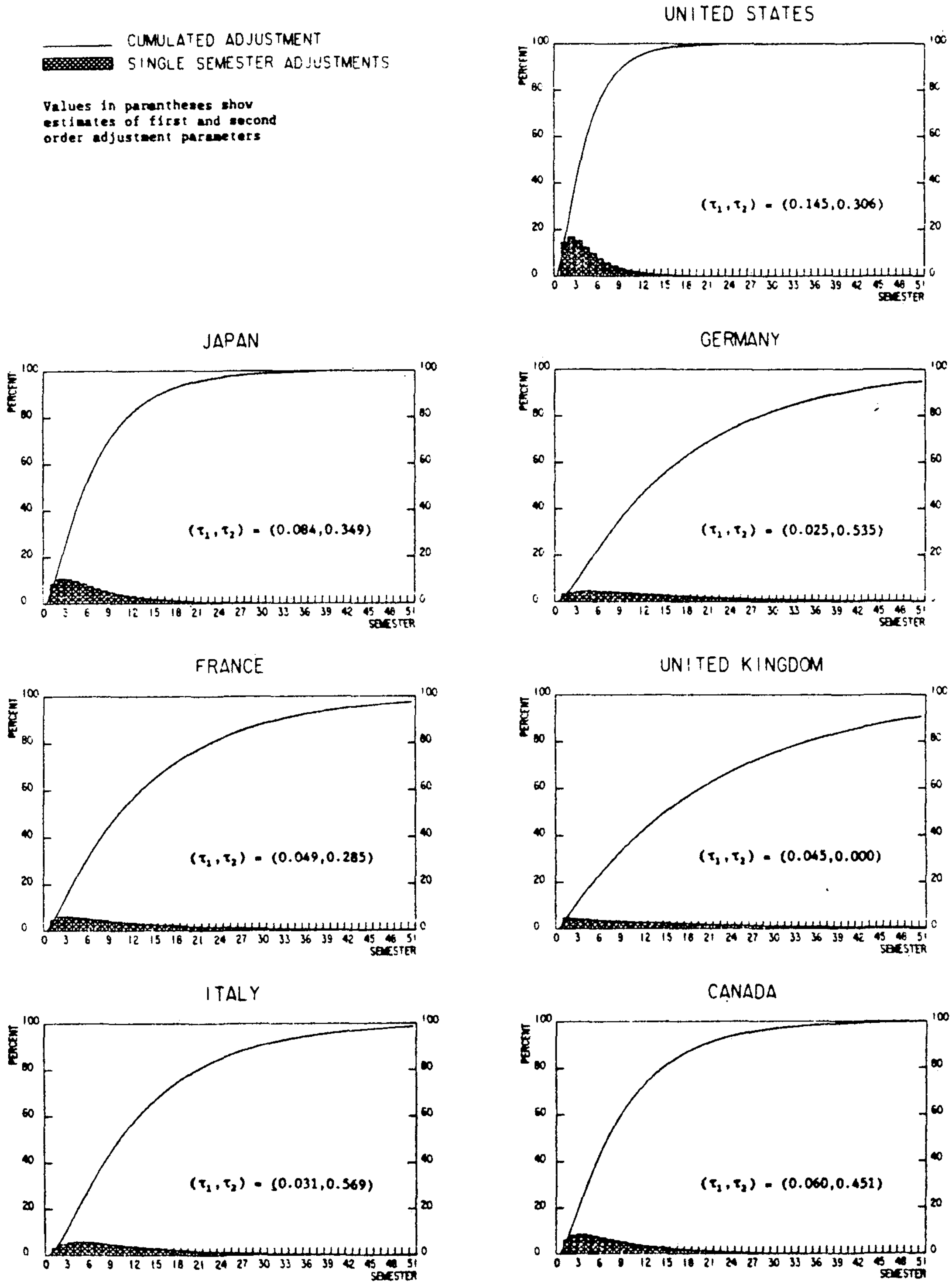
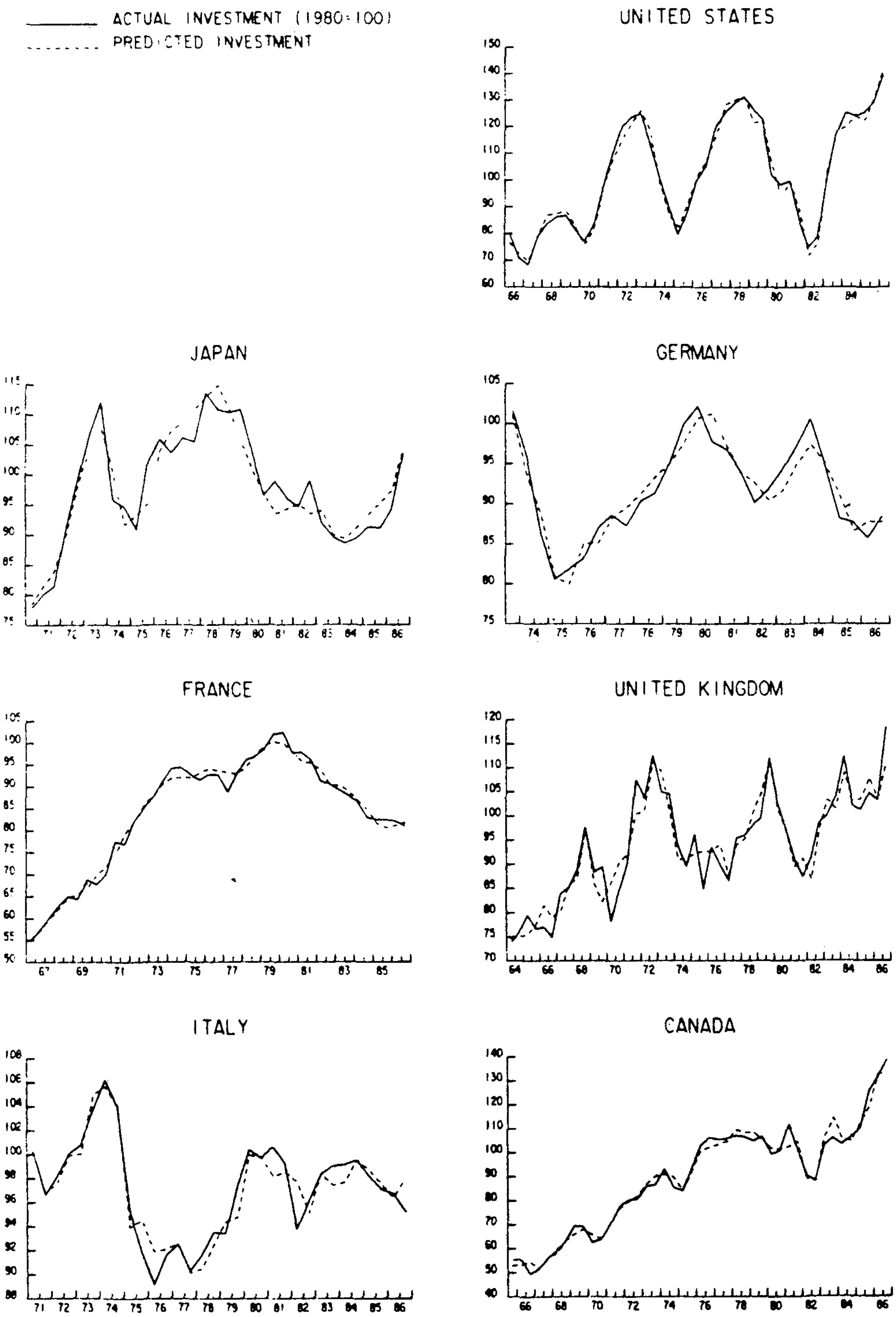


Figure 3

HOUSING INVESTMENT EQUATIONS: STATIC TRACKING PERFORMANCE



estimation by the inclusion of a dummy variable, which was found to be statistically significant at the 99 per cent level (26).

75. The estimates of long-run income elasticities for **Japan** are slightly above but not significantly different from unity. The per capita income term in the preferred equation is a two-period moving average. When the maximum lag is increased, the overall goodness-of-fit is reduced. Also, the second-order adjustment parameter, τ_2, increases and slight overshooting of the adjustment process is observed for some estimates.

76. The equation estimates characterise the Japanese housing market as the most sensitive of the seven major economies to changes in real interest rates. The interest rate used is an average of central government long-term bond rates, which differs substantially from the official interest rates charged on housing loans. Historically, the Housing Loan Corporation and, to some extent, ordinary banks have charged relatively stable "administered" mortgage rates which do not mirror movements in the rates charged elsewhere in the financial system. However, the substitution of a market-determined long-term rate by an actual mortgage rate (27) yields some marginal improvement in the standard error of estimate, with only slightly different coefficients. The significance of the market-based real interest rate is interpreted here as indicating the importance to Japanese households of alternative returns on financial assets.

77. For **Germany,** the preferred equation shows a long-run income elasticity of 0.93, the second lowest after that for the United States. However, altering the maximum lag on income or on the rate of change of the investment deflator entering the real interest rate term leads to both higher and lower elasticity estimates..

78. The average of rates on long-term public bonds used is highly correlated with the interest rates charged on mortgage bonds which finance a major part of German housing investment. In either case, the real interest rate terms, although correctly signed, are not statistically significant at the 95 per cent level.

79. The preferred equation was estimated on the basis of 27 observations, from the second half of 1973 to the second half of 1986. The same specification appears to be unstable when estimated over a longer sample period. There is evidence of a structural shift during 1973, and a standard Chow test rejects the hypothesis of stability over the subperiods 1964-73 and 1973-86 with a high probability. An equation which explains the growth of the housing stock in the latter subperiod underestimates growth in the 1964-73 period. There appears to be no satisfactory explanation of this shift.

80. Unlike the results for the other countries, relative price terms for Germany are not significant unless the highly significant unemployment term is omitted. In this case, the real housing service deflator is significant, but on goodness-of-fit criteria, such an equation is distinctly inferior to the chosen one.

81. For **France,** the estimated long-run income elasticity of the preferred equation is only slightly above unity, at 1.06, and is quite robust to changes in specification.

82. The estimated long-run interest rate semi-elasticity, at -0.43, is markedly lower than the unreasonably high value of the previous flow specification but, as for ermany, not significant at the 95 per cent level. This result is consistent with numerous studies of the French housing sector, which find either no interest rate influence or one present only in the short run. Introducing arbitrary dummies for periods where the largest residuals are observed (the first half of 1971 and the first half of 1977) raises the long-run interest rate semi-elasticity to -0.48 and a further increase to -0.57 can be induced by using longer moving averages in the income and current inflation terms. The overall goodness-of-fit is, however, reduced. Also, none of these differences is particularly pronounced or significant (28). An alternative series for the housing credit interest rate charged by banks was also tested, but proved inferior to the public sector bond rate.

83. The results for the **United Kingdom** are perhaps the least encouraging. Both the high estimate of the long-run income elasticity, at 1.41, and the low long-run interest rate semi-elasticity, at -0.25, are outliers compared to the estimates for the other countries considered and therefore warranted further investigation.

84. A range of alternative specifications were considered in examining the stability of the long-run income elasticity estimate. In general, as the maximum lag on income was increased, either the estimate of the short-run income effect, ψ_1, or the first-order adjustment coefficient, τ_1, became insignificant. Longer moving averages of the real investment deflator, PIH/PCP, tended to further raise the long-run income elasticity. If the statistically significant unemployment term is omitted, some reduction in the income elasticity (to 1.25-1.35) can be obtained, but at the expense of a substantial 1 percentage-point increase in the standard error of the estimate.

85. Historically, the flow of finance on the U.K. housing market has been dominated by the building societies, which have frequently rationed the demand for new mortgage credit in order to protect existing borrowers from the full effect of higher interest rates. In more recent years -- especially after the large-scale entry of commercial banks into the housing finance market in 1981-82 -- building societies appear to have shifted emphasis from credit rationing to using the interest rate to meet competition (see Drayson, 1987). To examine how changes in the supply of rationed credit may have influenced the estimates, a credit dummy, CRE, was added to the U.K. equation such that the growth rate of the capital stock of houses was assumed to be temporarily reduced in periods with tight credit (29). Thus:

$$(KHV(t)/KHV(t-1)) = [(KHV*(t)/KHV(t-1))^{**\tau_1}]*[(KHV(t-1)/KHV(t-2))^{**\tau_2}] \quad [14]$$

$$*EXP(\nu_1 * \Delta UNR(t)) + \nu_2 * (CRE(t)/KHV(t-1))$$

86. The long-run estimates of real interest rate sensitivity based on equation [14] were reduced by about one-third, compared with those of equation [13]. The preferred equation for the United Kingdom in Table 3 includes the credit dummy, which proved to be highly significant, with a coefficient of 0.36. Furthermore, estimates of equation [13] tended to produce much slower speeds of adjustment and even higher long-run income elasticities.

87. The preferred equation for the United Kingdom includes a 10-year government bond rate, which gives better overall results than an actual building society mortgage rate. With the latter included in the equation, the long-run interest rate semi-elasticity is reduced to -0.20. Using a nominal as opposed to a real interest rate produced higher interest rate semi-elasticities, but is hard to justify on theoretical grounds (30).

88. Given a number of problems associated with the data for **Italy** (31), the estimation results are surprisingly good, with the equation estimate showing the lowest overall standard error at 1.76 per cent. The long-run income elasticity is found to be very close to unity, at 1.02, with marginally higher and lower values obtained as the maximum lags are varied.

89. Estimates of the long-run interest rate semi-elasticity are low compared with the results for most other countries. The estimate, at -0.33, is the second lowest after that of the United Kingdom, but the coefficient estimate appears to be quite robust to changes in the specification of the equation.

90. The sample period for the preferred equation for Italy begins in 1970. Data are available starting in 1965, but if the equation is estimated over the full sample, very large residuals are observed in the period 1968-69 and the overall goodness-of-fit is substantially reduced. Another feature of estimates for Italy is the significance of the deflator for private consumption of housing services, PCPH, as a measure of expected inflation in the housing market, although the corresponding relative price term, PCPH/PCP, is insignificant. Results obtained with the housing service deflator replaced by the deflator for housing investment, PIH, are substantially worse than those reported, with a somewhat higher standard error, the long-run income elasticity rising to 1.17 and the long-run interest rate semi-elasticity reduced to -0.27.

91. The preferred equation for **Canada** is the only one where all variables included in the general specification enter significantly, although the overall standard error of the estimate is relatively high, at 4.1 per cent, compared with a simple average across countries of 3.1 per cent. Changes in the specification, however, influence the long-run income sensitivity only marginally, with most estimates found to be close to the reported value of 0.97.

92. Since interest payments are not tax-deductible in Canada, changes in interest rates may be expected to have a larger-than-average influence on the housing market. The long-run interest rate elasticity is indeed found to be the second highest after that for Japan, with an estimate of -1.19. The average Federal government long-term bond rate used in the preferred equation produces results superior to those obtained with a 5-year bank mortgage rate. Using the mortgage rate gives a higher long-term interest rate elasticity estimate but the equation fit deteriorates and the long-run income elasticity drops to values below 0.9.

3. Equation stability analysis

93. Table 5 reports cusum and cusum of squares stability test statistics for the set of preferred equations (32). For the United States, Germany, Italy and Canada stability cannot be rejected, even at the 90 per cent level. However, the chosen equations for Germany and Italy are estimated over a short

Table 5

STABILITY TESTS

	Degrees of freedom	Cusum		Cusum of squares	
		Backward	Forward	Backward	Forward
UNITED STATES	34	0.7200	0.4171	0.0808	0.1390
JAPAN	27	0.4201	0.8887*	0.3330**	0.2674*
GERMANY	21	0.8031	0.6318	0.1250	0.1256
FRANCE	34	0.2885	0.5207	0.2953**	0.2595**
UNITED KINGDOM	38	0.3801	0.8720*	0.2222*	0.3228***
ITALY	25	0.6425	0.7424	0.1613	0.1955
CANADA	35	0.4006	0.4289	0.1670	0.1803

Note: The tests have been carried out under the hypothesis that the dummies and the auto-correlation parameters are stable. Dummies have been deducted from the constant (using estimated coefficients) and where the equations have been estimated with correction for autocorrelation, transformed data are used.

* Hypothesis of stability rejected at the 90% level.

** Hypothesis of stability rejected at the 95% level.

*** Hypothesis of stability rejected at the 99% level.

sample. If a full sample is used, as pointed out earlier, the estimated equations for the two countries are also unstable. Hence, taken together the stability performance of the estimates is not satisfying in a majority of countries, but, given the complexity of housing markets and the notorious difficulties in modelling aggregate housing in a similar way across countries, this result is not surprising.

94. For Japan and France, stability is rejected at the 95 per cent level, and for the United Kingdom, at the 99 per cent level. An examination of the estimated coefficients using recursive regressions reveals that the instability of the Japanese equation is largely associated with the speed of adjustment of the actual to desired housing stock, which tends to fall over time. Although the stability of the Japanese equation can be improved by adding a time trend in the adjustment process, this is unsatisfactory in the absence of a plausible underlying explanation.

95. For France it is the estimated adjustment profile -- determined by the interaction of the adjustment parameters τ_1 and τ_2 -- rather than the speed of adjustment which fluctuates in recursive regressions. Over time, the tendency is one from higher to lower then back to higher initial reactions. The estimates of real interest rate and relative price terms do not seem to fluctuate any more than for other countries where stability is not rejected.

96. Eliminating the unemployment term, the equation for the United Kingdom seems stable, although the instability of the preferred equation does not appear to originate in the unemployment term. Rather, the main source of variation over time is in the interest rate term, independent of whether the unemployment rate is included or not. There is some tendency towards higher speeds of adjustment when beginning- or end-sample observations only are used. Chow-test statistics for all possible break points in the sample period do not, however, reject the hypothesis of stability across break points. This suggests that the results for the United Kingdom should be treated with some care.

4. Implementation

97. The implementation of the new estimation results in INTERLINK requires two equations for each country -- one to determine the stock of houses, KHV, and the other the flow of investment, IHV. These involve an identity, linking the developments of stocks and flows, and a behavioural equation, which can be expressed in terms of either IHV or KHV. Given a focus of interest on the investment flow in the context of short-term forecasting applications, IHV was chosen as the behavioural variable in the model, arrived at through the substitution of equation [13] into equation [11]. Thus:

$$
\begin{aligned}
IHV(t) = 2*[\exp[\psi_0 &+ \tau_1*\ln(POPT(t)) + \psi_1*\ln(M(YDRH(t)/POPT(t))) \qquad [15] \\
&+ \psi_2*(M(\langle IR(t)\rangle)-M(\dot{P}^e(t))) \\
&+ \psi_3*\ln(M(PCPH(t)/PCP(t))) + \psi_4*\ln(M(PIH(t)/PCP(t))) \\
&+ (1+\tau_2-\tau_1)*\ln(KHV(t-1)) - \tau_2*\ln(KHV(t-2)) \\
&+ \nu_1*\Delta UNR(t)] - (1-RSCRH(t)/200)*KHV(t-1)]
\end{aligned}
$$

where exp is the exponential operator. KHV is then determined residually through the identity [11].

98. For the United States, Japan, France, Italy and Canada, where the deflator for private consumption of housing services, PCPH, is introduced as a new variable in the model, equations linking PCPH to the overall consumer price deflator, PCP, were estimated and implemented. For the United States, an equation linking the mortgage interest rate to the AAA corporate bond rate is also included. All of these bridging equations are described in Appendix C.

5. Simulation experiments

99. In order to assess the influence of the new housing stock equations for overall model properties, a range of simulation experiments were carried out and Appendix D reports the results of standard fiscal and monetary shocks

for each of the relevant INTERLINK submodels. These were performed in single-country mode (i.e. for given "world" assumptions) and the tables provide a comparison of multipliers for models including the estimated stock-adjustment and the former flow-based housing equations.

100. More specifically, reactions over a ten-year simulation period, 1980-1989 were calculated for two shocks. The first simulates a sustained increase in real fiscal expenditure equal to 1 per cent of real gross domestic output, with fixed exchange rates and fixed nominal interest rates. The second simulates the effects of a sustained 1-percentage-point reduction in short-term interest rates, with fixed exchange rates and fixed real government expenditures. For the United States and Japan, where yield curve effects were included in the previous flow-based equations, further simulations of the effects of a sustained 1-percentage-point reduction in the long-term interest rate, with fixed exchange rates and fixed real government expenditures, are also reported.

101. For the fiscal shock, the results show that the replacement of the flow equations with stock-adjustment equations does not have any great impact upon aggregate fiscal multipliers for any of the seven country models. The largest changes occur for Japan and the United States, where real GNP reacts somewhat more with the stock-adjustment equations. Similar, but less pronounced, changes occur for Germany and the United Kingdom. These differences reflect housing investment reactions which, at their peak, are almost three times higher for Japan and twice as high for Germany, the United States and the United Kingdom, than in the former models.

102. For France and, to a lesser extent, Canada, there is a small reduction in the investment multiplier when moving from a flow to a stock equation. In the case of France, where the long-run income elasticity is five times lower than in the former model, the multiplier is now more in line with those of the other European countries. For Italy, the investment multiplier is now smaller initially, but larger by the end of the sample period.

103. For short-term interest rate shocks, the models for Italy, Canada, France and the United Kingdom show somewhat reduced reactions with the stock-adjustment equation. This is consistent with the lower real interest rate sensitivity in the stock equations for these countries. For the United Kingdom, the investment multiplier turns negative after five years, and the housing stock is below baseline by the end of the simulation period. Previously, high real interest rate elasticities in the flow equation more than outweighed the negative impact on residential investment coming from reduced real disposable household income, which is no longer the case. For Italy and France, the investment multipliers with the new housing submodel are lower than previously, throughout the sample period, whereas for Canada, the housing investment effects are generally lower beyond the second year.

104. For both Germany and Japan, the models show a substantially stronger sensitivity to changes in short-term interest rates. This result is not unexpected, since direct real interest rate effects were previously absent from the flow equations for Japan and relatively modest for Germany. Finally, in the case of the United States, the differences between multipliers in the two models are most pronounced at the end of the sample period, where real GNP returns almost to baseline levels with the stock-based equation.

105. More pronounced differences are observed for the multipliers of long-term interest rate shocks. Both for Japan and the United States, substantially higher real GNP effects are given by the revised models. This result reflects perverse investment responses previously embodied in the flow-based equations, in which the steepness of the yield curve entered as an influence on housing investment.

IV. CONCLUDING REMARKS

106. Special features of the housing sector make dwellings one of the most difficult expenditure components to model. There appears to be little consensus on the exact functioning of housing markets or the most appropriate model specifications for aggregate residential investment. In practice, a wide range of approaches and specifications coexist, with empirical models often focusing on the demand side of the market, usually under the assumption of perfectly elastic supply in the long run. Thus, it is found that household income, population, real house prices and interest rates are commonly used explanatory variables. Household wealth, credit rationing variables and the unemployment rate are also included by some researchers.

107. The empirical results presented in this paper for the seven major OECD economies relate to the determination of housing stocks, in contrast with the previous equations in the OECD INTERLINK model, which like many other macroeconomic models contained equations for the flow of housing investment. The stock approach is, however, considered to be superior on theoretical grounds, with long-term properties being more transparent. Using a second-order stock-adjustment model, the empirical estimates obtained in this study confirm the findings of many other researchers -- that real after-tax income is a key determinant of residential investment, with the estimated long-run elasticities for real housing stock demand relatively close to unity for most of the countries considered.

108. Financial market influences were also found to have an important impact on housing activity, as indicated by the significance of real interest rate estimates obtained for most countries. No attempt was made to incorporate the effects of tax concessions on mortgage interest rates and, with the exception of the United States, it did not prove necessary to introduce mortgage lending rates as opposed to long-term bond rates into the equations. The significance of real interest rates contrasts with the results embedded in the previous set of flow equations in INTERLINK, where robust estimates of interest rate effects could not be obtained for many countries. Averaged across countries, the revised long-run interest rate sensitivity is nonetheless lower, possibly reflecting the important difference in dynamics introduced with the stock specification.

109. The estimated interest rate elasticities obtained vary widely across countries, possibly due to the differing institutional arrangements. Given the effects of credit squeezes on the availability of mortgage finance, credit dummies were introduced and found to be significant for the United States and the United Kingdom.

110. Significant relative price terms appear in the equations for all countries except Germany. The deflator of residential investment relative to consumer prices proved to be significant in four countries, with little dispersion in the long-term elasticities. Greater dispersion across countries is observed for the elasticity of housing demand with respect to the price of housing services relative to consumer prices, which again proved to be significant in four countries.

111. The overall tracking performance of the new equations was found to be generally satisfactory, given the relatively sharp fluctuations in housing investment in some countries. This may in part be due to richer dynamics incorporated in the stock adjustment mechanism, which may be sufficient to capture the most important short-term supply-side developments. Additional short-term effects associated with household uncertainty, proxied by changes in the unemployment rate, are also identified in the equations. The equation estimates are, however, found to be somewhat unstable for a number of countries, possibly reflecting the non-homogeneous nature of the housing market and institutional changes in credit markets during the estimation period.

112. At an aggregate level, model simulation properties with respect to fiscal and monetary policy shocks were found to change only marginally with the introduction of the new equations into the INTERLINK model -- an unsurprising result given housing's relatively low weight in GNP. An exception to this general finding concerns long-term interest rate simulations, which now give more uniform results across countries.

113. Finally, this paper has shown that reasonable estimates can be obtained applying a common stock-adjustment approach to housing in seven major countries, with widely different institutions supporting their individual housing markets. These results are encouraging.

NOTES

1. Richardson (1988) summarises the principal features of the OECD INTERLINK model. A detailed guide to the most recent developments in the overall structure and simulation properties of INTERLINK are given by Richardson (1987a, 1987b). Llewellyn <u>et al.</u> (1985) discuss the general background, role and functions of INTERLINK in OECD work.

2. The service lives of dwellings are typically assumed, in National Accounting terms, to be between 50 and 100 years (see Blades 1983, Table 5) and for most countries, housing investment in any given year adds little more than 1 per cent to the existing stock.

3. Arcelus and Meltzer (1973) make such a distinction: their model is essentially a three-equation system specifying the demand for housing services, and the supply and demand of new housing units.

4. The extent of owner occupancy varies considerably across OECD countries, reflecting the diversity of institutional arrangements which affect the tenure choice decision. Owner occupancy is lower in Europe (Germany, 40 per cent; France, 51 per cent; England, 65 per cent), than outside Europe (United States, 66 per cent; Australia, 70 per cent) (see Table 1 of Coleman, 1988).

5. Land prices are particularly important in a number of OECD countries; in Japan, for example, land costs account on average for approximately one-third of acquisition costs -- much higher than for other OECD countries (see Rosen, 1988).

6. Poterba (1984) suggests that where the opportunity cost of investing in alternative assets differs from the cost of borrowing for house purchase, the interest foregone on the owner's equity is also part of the cost of housing services.

7. These intertemporal aspects can be analysed theoretically in a framework in which households are assumed to maximise consumption of lifetime housing services subject to a multi-period budget constraint incorporating borrowing possibilities (see for example Artle and Varaiya, 1978).

8. For example, in the United States, the share of improvements in new residential construction put in place increased from 21 per cent in 1965 to 30 per cent in 1980 (see Smith et al., 1988, Table 1). In Japan, the corresponding percentage is much higher: about half of the owner-occupied houses contructed between 1978 and 1983 were replacements for existing dwellings (see Chapter III in Economic Planning Agency, 1986).

9. Muth and Wetzler (1976) estimated that building codes alone add nearly 2 per cent to building costs in the United States.

10. Local authority housing, for example, is important in the United Kingdom. In England and Scotland, the share of public rented dwellings in 1985 were 26 and 50 per cent, respectively (see Coleman, 1988).

11. The importance of a wide range of such factors is discussed in a recent survey article by Smith et al. (1988).

12. Examples are the American Harvard Urban Development Simulation model (Kain and Apgar, 1985), the German IFO model (Behring and Goldrian, 1985) and the Dortmund Simulation model (Wegener, 1985).

13. The French models SABINE (180 equations, 140 estimated) and FANIE (56 equations, 38 estimated) are typical examples (see Lefebvre and Mouillart, 1986). Both models incorporate the constraints faced by households in the housing market and focus on the effects of government intervention and the influence of financial factors. In the case of SABINE, spill-over effects from rationed financial resources to the demand for dwellings are modelled directly, whereas FANIE models household decision-making in a hierarchical order -- one where the acquisition of financial resources precedes and influences demand. Residential investment is determined at a disaggregated level, and both models contain equations for starts and sales of new houses in subsidised and non-subsidised sectors of the market.

14. The existing stock of houses may be included, for instance as a scaling factor for other explanatory variables in the supply equation (Jaffee and Rosen, 1979).

15. Explanatory variables such as interest rates may nonetheless be perceived as representing both a demand- and a supply-side influence. Hendry (1984), for example, specifies a house price equation incorporaing both demand- and supply-side effects.

16. Many modellers of housing subscribe to this view. Poterba (1984) and Rosen and Topel (1986) argue that the long-run production possibility frontier between houses and other goods is not flat, because some production factors in the construction industry are in limited supply. Wiesmeth (1985) and Goodwin (1986) question the capability of prices to rapidly clear the market in the short run, claiming that prices are rigid. To incorporate the rigidity of prices, Wiesmeth employs the notion of fix-price equilibria, as developed by Benassy (1975) and Drèze (1975), to describe the housing market in the short run. Goodwin develops an aggregate empirical macroeconomic two-market (housing and credit) model, with rationing and spillover effects across markets. De Rosa (1978), Hendershott (1980) and Behring and Goldrian (1985) maintain that the short-run housing market should be modelled as a market in disequilibrium -- largely because of credit rationing.

17. Goux (1983) develops a stock-adjustment model with endogenous speed of adjustment, but his τ-function includes mainly demand-side influences.

18. Grady Economics and Associates (1985) examines the structure of eleven Canadian macroeconometric models. Of these, nine have separate housing investment equations: the CANDIDE model of the Economic Council of Canada, the TIM model of the Informetrica Ltd., the Research Department Experimental Forecasting Model (RDXF) of the Bank of Canada, the second version of the Research Department Experimental Model (RDX2), the CHASE econometric model of Chase Econometrics, the DRI model of the Data Resources, Inc. Canada, the Forecasting and User Simulation Model (FOCUS) of the Institute for Policy Analysis, University of Toronto, the Medium-Term Quarterly Forecasting and Simulation Model (MTFM) of the Conference Board of Canada and the Quarterly Forecasting and Simulation Model (QFS) of the Department of Finance. QFS has since been replaced by the similarly structured CEFM (see Stokes, 1987)

19. This distinction is used in Hendershott (1987) and Dicks (1988). In a model of the demand for owner-occupied housing units in the United States, Jaffee and Rosen (1979) also control for the number of owner-occupied units which would have resulted from unchanged age-specific rates of owner occupancy.

20. So-called "hedonic" prices (see Rosen, 1984).

21. See Chouraqui et al. (1988) for a review of interest-rate sensitivity in macroeconomic models for nine OECD countries.

22. Males and females in the age group of 15-64 years. The demographic influence is represented by the working age population, because developments in household formation are considered to be more closely linked to the active work force than total population growth.

23. If the estimates of ψ_1 (the short-run income elasticity) and τ_1 (the first-order adjustment parameter) for the United Kingdom are, respectively, lowered and raised by two standard errors, the long-run income elasticity estimate falls to 0.92.

24. For an overview of the relevant statistical methods in OECD countries, see OECD (1984).

25. It should be noted that the speed of adjustment of the desired capital stock of houses, KHV*, to changes in individual explanatory variables also differs across countries.

26. The dummy variable is based on a quarterly variable, set to unity in quarters when deposits at savings and loans associations fell and zero otherwise. It is assumed that credit rationing ceased in the late 1970s, with the dummy variable set to zero thereafter.

27. The mortgage interest rate used for Japan is a weighted average of the Housing Loan Corporations rate and the City Bank housing loan rate, using weights reflecting the sample average period of flow of funds for housing purchase from these two institutions.

28. If the alternative estimates are reduced by one standard error, then the alternative long-run interest rate semi-elasticities drop below that reported in Table 3 for France.

29. The dummy is based on a quarterly series for the real value of building society loans. Expressed at semi-annual rates, the loan variable is first normalised by dividing by the lagged stock of houses, KHV(t-1). The real value of loans in the first half of 1983 is then deducted throughout the period, assuming no credit rationing to have occurred after 1983. Positive values before 1983 are set to zero. A credit dummy similar to that used in the estimation for the U.S. equation was tested without success.

30. If higher inflation raises subjective uncertainty concerning future price developments, fluctuations in the user cost of housing may have been overestimated for the United Kingdom, where inflation in the past has been quite high, and furthermore unstable.

31. Revised national accounts were only available from 1980 onwards and were spliced with appropriately rescaled series based on previous national accounts data.

32. The analysis of this section is based mainly on the technique of recursive regression, where the equation examined is estimated over all possible subsamples, including either the first observation (forward regression) or the last observation (backward regression). These estimates are used to calculate a set of recursive residuals, which, if the original disturbances are independently and identically distributed, will themselves be independently and identically distributed. This permits the use of recursive residuals in tests for structual change over time, of which the cusum and cusum of squares tests are reported here. Further details on the calculation of recursive residuals and associated test statistics are given by Johnston (1985, pp. 384-92) and the references therein.

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Appendix A

A SUMMARY OF KEY FEATURES OF HOUSING INVESTMENT EQUATIONS

The following table summarises key features of housing investment equations in recent empirical studies for the major seven OECD economies. The studies and models cited are listed in the bibliography to the main text.

General Notes

Numerical values in brackets refer to long-run elasticity estimates, where these are clearly identified.

"Flow/stock" indicates that the housing stock either enters as an explanatory variable in the flow equation or influences housing investment through a house price equation in the overall model.

Equations are labelled as "stock" when based on a stock-adjustment model although the dependent variable may sometimes be the flow variable.

"Demand/supply" refers to the housing market model, rather than associated financial markets.

Demographic factors normally enter housing equations through the specification of other variables in *per capita* terms. Where the demographic variable enters separately, a sign/elasticity is reported in the table.

"Current/permanent" means that income enters in a distributed lag form, although it is often unclear whether such terms should be interpreted as representing permanent income.

"n.s." indicates coefficient values which were reported as being not significant.

Table A

A SUMMARY OF KEY FEATURES OF HOUSING INVESTMENT EQUATIONS
IN RECENT EMPIRICAL STUDIES FOR THE MAJOR SEVEN OECD ECONOMIES

STUDY/MODEL	TYPE OF HOUSING EQUATION(S)	DEMOGRAPHIC FACTORS	HOUSEHOLD INCOME	PRICES	FINANCIAL FACTORS	OTHER FACTORS
USA						
Arcelus and Meltzer (1973)	Flow (services) Demand	None	Permanent (0.94)	Rent index (-0.51) GNP deflator (0.91)	None	Real base money (n.s.) Real government debt (-0.15)
	Flow (starts) Supply	None	Indirectly, through services	Rent index (3.68) House price (0.29)	Nominal bond rate (-2.05)	Real labour cost of construction (-0.95)
	Flow (starts) Demand	None	Indirectly, through services	Rent index (4.35) House price(-0.40)	Nominal bond rate (-1.75) Real mortgage stock (-0.69)	Real base money (0.71) Real government debt (-0.24) Expected demand for housing services (0.66)
De Rosa (1978)	Stock Demand Portfolio adjustment model	None	Current (+)	Real house price (-) Real price of consumer durables (+)	Nominal time and savings rates (-) Nominal bond rate(-) Nominal mortgage rate (-)	Savings, capital gains and excess demand for other assets
Jaffee and Rosen (1979)	Stock (number of owner-occup. houses) Demand Stock adjustment	Age-distributed population	None	Price of home ownership rel to rent index (-)	Real credit flows(+)	Unemployment rate (-)
	Flow/stock (single-family starts) Demand	Age-distributed population	None	Credit variables deflated by house price	Nom. mortgage rate(-) Real credit flows (+)	Demand for owner-occup. houses (+) Stock of single-family houses (+)
	Flow/stock (multi-family starts) Supply	None	None	Real rent index (+)	Real mortgage rate(-) Real credit flows (+)	Vacancy rate (-) Stock of multi-family houses (-)
Kearl[1] (1979)	Flow/stock Demand/supply	Number of households	Permanent, per household (1.29)[2]	Through interest term	Real after-tax mortgage rate (-)	Initial mortgage payment (-1.70)[2] Owner's equity per household (1.03)[2] Housing stock per household (-8 76)

Hendershott (1980)	Rate of owner-occup. Demand	Age-distributed population Number of households	Current, per household (n.s.)	Rent index (see "financial factors")	Real after-tax mortgage rate rel to rent index (-)	
	Flow (one-to four-family starts) Demand	Indirectly	None	Indirectly	Credit flows (+) Mortgage rate (indirectly)	Number of homeowners (+)
	Flow (quality of starts)	Number of households	Current, per household (0.36 - 0.68)	Interest term scaled by real house price	Real after-tax mortgage rate (-0.10 - -0.22)	Mortgage payment constraint (-0.16 - -0.43)
Poterba[3] (1984)	Flow (one-family only) Supply	None	None	Real house price (0.52-2.92) Non-residential construction deflator (-0.93 - +3.13)	Credit flows (0.38 - 0.48) Credit dummy (mixed signs)	Real construction wage (mixed signs)
Henderson and Ioannides (1986)[1]	Flow (services) Demand	Household survey data	Current (0.38 - 0.45)	Rent index (0.33 - 0.45)	Real rate of interest (-0.81)	
Goodwin (1986)	Flow (number of one-family houses sold) Supply	None	None	House price rel to cost index (-)[4]	4-6 mo. rate on prime commercial paper(+)[4]	Average sales period(-) Vacancy rate (-)
	Stock (number of one-family houses sold is modelled) Demand Stock adjusment	Number of households (+)	Permanent(+)	Real house price (+)[4]	Nominal mortgage rate (-)[7]	Marginal income tax rate (+)
Charpin[5] (1987)	Stock (per capita) Demand Stock adjustment	Total population	Permanent, per capita (0.85)	Real investment deflator (n.s.)	Real mortgage rate (-0.21)[7]	Unemployment rate (-1.01)[6]
MPS model Brayton and Mauskopf (1985)	Stock (inv. per capita is modelled) Demand Stock adjustment	Total population	Permanent, per capita (0.84)	Interest term scaled by real house price	Weighted nominal and real after-tax mortgage rate (-0.69) Credit flows in dummy	Unemployment rate (-7.28)[6,7]
MCM model[5] Edison et al. (1987)	Flow/stock (net) Demand Flow adjustment	None	Current (>1)	Through interest term	Real after-tax mortgage rate (-)	A fraction of the lagged housing stock deducted from gross investment

Table A (cont.)

A SUMMARY OF KEY FEATURES OF HOUSING INVESTMENT EQUATIONS
IN RECENT EMPIRICAL STUDIES FOR THE MAJOR SEVEN OECD ECONOMIES

STUDY/MODEL	TYPE OF HOUSING EQUATION(S)	DEMOGRAPHIC FACTORS	HOUSEHOLD INCOME	PRICES	FINANCIAL FACTORS	OTHER FACTORS
EPA world model[5] (1987)	Stock (net investment is modelled) Demand Stock adjustment	None	Current (≈1)	Interest term scaled by real investment deflator	Real mortgage rate(−)	
JAPAN						
Charpin[5] (1987)	Stock (per capita) Demand Stock adjustment	Total population (1.56)	Permanent, per capita (0 45)	Income scaled by real investment deflator	Real mortgage rate (n.s.)	Unemployment rate (n.s.)[6]
EPA world model[5] (1987)	Stock (net housing is modelled) Demand Stock adjustment	None	Current (≈0.8)	Income deflated by investment deflator	Real mortgage rate (≈−0.7)[7]	
MCM model[5] Edison et al. (1986)	Flow/stock (net) Demand Flow adjustment Accelerator term	None	Current/permanent Accelerator term (+)[6]	Through interest term	Real after-tax mortgage rate (>>−1)[7]	Real net wealth (+) Housing stock[8]
GERMANY						
Charpin[5] (1987)	Stock (per capita) Demand	Total population (0.91)[6]	Permanent (0.30)[6]	Real investment deflator (−0.15)[6]	Real interest rate (n.s.)[6]	Unemployment rate (n.s.)[6]
SYSIFO model Univ. of Hamburg (1982)	Flow/stock Demand/supply Flow adjustment	Total population	Current/permanent per capita[9]	Through interest term	Real after-tax interest rate rel. to consumer deflator[9]	Housing stock per capita[9]
Deutsche Bundesbank Model (1988)	Flow/stock Demand/supply Flow adjustment	None	Current (0.20)[6]	Interest term scaled by real investment deflator	Real after-tax bond rate (−0.20)[6]	Rate of indirect taxes to final demand (−)[6] Housing stock (−)[6]

EPA world model[5] (1987)	Stock (investment is modelled) Demand Stock adjustment	None	Current/permanent (0.89)	Through interest term	Real mortgage rate (-1.15)[7]	Real financial net worth (0.10)
MCM model[5] Edison et al. (1986)	Flow/stock (net) Demand Flow adjustment Accelerator term	None	Current/permanent (+)[6]	Through interest term	Real after-tax interest rate (>>-1)[7]	Housing stock[8]
FRANCE						
Goux (1983)	Stock (per capita) Demand/supply Stock adjustment with endogenous speed	Population, 20-65 yrs. of age No. of marriages(+)[6]	Permanent, per capita (0.81 - 0.83)	Independent inflation term (+)[6] Interest term influenced by house price	Real interest rate (-)[6] Nominal bond rate (n.s.)[6] Credit variables (n.s.)[6]	Unemployment rate (n.s.)[6] Temporary income (n.s.)[6]
MELO model Mouillart and Salmon (1987)	Flow (non-subsidised starts for rent) Supply Flow adjustment	None	None	None	Nominal bond rate (>>-1)[7]	
	Flow (non-subsidised starts for purchase) Demand	Total population	Current, per capita (+)	Income deflated by cost index	Real bond rate (>>-1)[7]	Unemployment rate (>>-1)[7]
Charpin[5] (1987)	Stock (per capita) Demand Stock adjustment	Total population	Permanent, per capita (0.89)	Real investment deflator (-0.47)	Real mortgage rate (-0.10)[7]	Unemployment rate(n.s.)[6]
METRIC model Artus et al. (1981)	Stock (non-HLM starts per capita is modelled) Stock adjustment	Total population	Permanent, per capita (salary income: 0.87-1.01; non-salary income: 1.73 - 2.01)	Real house price (-0.91)[7]; -2.80[6,7]) Independ. inflation term (1.64 - 1.71)[7]	Nominal or real mortgage rate (n.s.) Subsidies (+) Credit ceiling rate(+)	
COPAIN model Dehove (1981)	Stock Demand Stock adjustment with endogenous speed	Population, more than 20 yrs. of age (1, imposed)	Permanent, per capita (0.72)	Income and liquidity deflated by investment deflator	Real liquidity (+)[6]	
DMS-4 INSEE (1987)	Stock (non-HLM) Demand Stock adjustment	Population, more than 20 yrs. of age (1, imposed) Population growth (+)[6]	Permanent, per capita (0.97)	Income defl. by house price Indep. inflation term is signif. (+)[6], but is left out	Real interest rate (n.s.)	

Table A (cont.)

A SUMMARY OF KEY FEATURES OF HOUSING INVESTMENT EQUATIONS
IN RECENT EMPIRICAL STUDIES FOR THE MAJOR SEVEN OECD ECONOMIES

STUDY/MODEL	TYPE OF HOUSING EQUATION(S)	DEMOGRAPHIC FACTORS	HOUSEHOLD INCOME	PRICES	FINANCIAL FACTORS	OTHER FACTORS
UNITED KINGDOM						
Hendry (1984)	Stock (no. of owner-occupied houses) Demand Derived from house price equation[3]	Number of households (1, imposed)	Current, per household (1, imposed)	Real house price (-0.27) Indep. inflation term (0.7)[7]	Nominal after-tax market rate (-0.4)[7] Mortgage stock rel. to income (0.27)	
National Institute model-7 (1984) Easton and Patterson (1987)	Flow[10] Demand Flow adjustment	None	None	Interest term scaled by real house price House price inflation rel. to interest rate on local authority debt (0.4)[7]	Real after-tax mortgage rate (≈-1.7)[7] Real credit flows (+)	
HM Treasury model (1984) Easton and Patterson (1987)	Flow (net of local authority capital grants)[10] Demand/supply Flow adjustment	None	None	Real house price (≈3.7)	Nominal interest rate (≈-1.1)[7]	
LBS model (1984) Easton and Patterson (1987)	Flow Demand/supply Flow adjustment	None	Current (0.42)	Real house price (0.57)[6]	Nominal clearing bank base rate (-8.68)[7]	
Bank of England model Patterson *et al.* (1987)	Flow/stock[10] Demand Flow adjustment	None	Current (+)	Real house price (-)	Real after-tax bond rate (-) Real credit flows (+)	Net liquid assets to income ratio (+) Housing stock through house price equation[3]
MCM model[5] Edison *et al.* (1986)	Flow/stock (net) Demand	None	Current/permanent (>1)	Indep. inflation term (>>1)[7]	Real after-tax mortgage rate (>>-1)[7]	Housing stock[8]

ITALY						
Banca d'Italia model (1986)	Flow/stock (inv. is modelled) Demand/supply Flow adjustment	Total population	None	Demand pressure minus investment inflation (+)	Real bank interest rate (-)	Housing stock per capita (-) Demand pressure divided by housing stock (+)
	Stock Demand Stock adjustment	Total population	None	None	Yield on houses rel. to financial investments (+) Credit rationing	Housing stock per capita (+) Household wealth (+)
Charpin[5] (1987)	Stock (per capita) Demand	Total population (1.20)[6]	Permanent, per capita (0.27)[6]	Income term scaled by the real invest. deflator	Real interest rate (n.s.)[6]	Unemployment rate (n.s.)[6]
CANADA						
RDX2 model (1976)[11]	Flow/stock (starts) (Demand/supply)[12,13]	None	None	Credit flows defl. by investment defl.	Real credit flows (+)	
CANDIDE model (1979)[11]	Flow (single-family starts)[12,13] Demand/supply	Population, 30-34 yrs. of age (+)[6]	None	Cost of home ownership rel. to rent index (+) Credit flow deflat. by invest. deflat.	Real credit flows (+)	
	Flow (multi-family starts)[12,13] Demand Flow adjustment	Population, 25-29 yrs. of age (+)[6]	None	Credit flow deflat. by invest. deflat.	Real credit flows (+)	
FOCUS model (1982)[11]	Flow/stock (starts)[12,13] (Demand/supply)	None	None	Credit flow deflat. by invest. deflat.	Real credit flows (+)	
DRI model (1983)[11]	Flow/stock[13] (starts per capita) Demand/supply	Population, more than 15 yrs. of age (1, imposed)	Current[9]	House price[9] Real rent index[9]	Nominal mortgage rate[9] Real credit stock[9]	Stock of houses[9]
RDXF model (1983)[11]	Flow/stock (starts)[13] Supply	None	None	House price (1.28) Cost index (-0.94)	Nominal chartered bank prime lending rate (-7.98)[7]	Stock of houses through house price equation[3]

Table A (cont.)

A SUMMARY OF KEY FEATURES OF HOUSING INVESTMENT EQUATIONS
IN RECENT EMPIRICAL STUDIES FOR THE MAJOR SEVEN OECD ECONOMIES

STUDY/MODEL	TYPE OF HOUSING EQUATION(S)	DEMOGRAPHIC FACTORS	HOUSEHOLD INCOME	PRICES	FINANCIAL FACTORS	OTHER FACTORS
TIM model (1984)[11]	Flow/stock (starts)[13] Demand	Number of one-person households Number of multi-family households	Current/permanent	House and land prices in mortgage payment	Nominal mortgage rate in mortgage payment Real commercial paper interest rates (long)[9]	
CHASE model (1984)[11]	Flow/stock (starts per capita)[13] Demand/supply Stock adjustment	Population, more than 15 yrs. of age	Current, per capita (2.18)[2]	House price rel. to cost index (0.35)[2]	Nominal mortgage rate (-6.07)[2,7] Stock of houses through house price equation[3]	Housing stock per capita (-3.45)
MTFM model (1984)[11]	Flow/stock (single-family starts)[13] Supply	None	None	House price[9] Cost index[9] Indep. inflation term[9]	Chartered bank prime lending rate[9]	Unemployment rate[6,9] Stock of houses through house price equation[3]
	Flow/stock (multi-family starts)[13] Supply	None	None	Rent index rel. to user cost of rental houses[9] House price rel. to cost index[9]	Real after-tax interest rate in user cost for rental houses Nominal mortgage rate[9]	Stock of houses through house price equation[3]
CEFM model Stokes (1987)	Flow/stock (single-family starts)[13] Supply	None	None	House price[9] Cost index[9]	Real chartered bank prime lending rate[9] Credit availability[9]	Unemployment rate[6,9] Stock of houses through house price equation[3]
	Flow/stock (multi-family starts)[13] Supply	None	None	Rent index[9] Interest term scaled by cost index	Real after-tax interest rate charged to business companies[9] Real chartered bank prime lending rate[9] Credit availability[9]	Stock of houses through house price equation[3]
MCM model[5] Edison et al. (1987)	Flow/stock Demand Accelerator term	None	Current/permanent (+)[6]	Through interest term	Real bond rate (<-1)[7]	Housing stock (+)

Notes to Table A

1. Estimations using alternative specifications are reported. The results shown in the table refer to either the equation explicitly preferred by the author(s) or the equation with the best statistical fit or the equation used as the basis for numerical conclusions in the study under consideration.

2. Short-term elasticities, disregarding the specified interaction between housing investment and the housing stock term in the equation.

3. The house price equation is important in this study/model. The price of houses is usually determined by a conventional Walrasian price-adjustment equation as a function of excess demand for houses, where demand in general is explained by population, income, prices and interest rates, and supply by the existing stock of houses.

4. Recognised to be contrary to theory.

5. Multi-country study/model.

6. Short-term (impact) elasticity; effect only present in the short run.

7. Semi-elasticity.

8. See "other factors" under the MCM model for the United States.

9. Sign of estimated coefficient is not published.

10. The equation for housing investment/housing starts interacts with equations for the price of houses, interest rates and flow of funds between institutional sectors.

11. See Grady Economics and Associates (1985).

12. Housing investment in RDX2, CANDIDE and FOCUS is very closely linked to the flow of credit. Explanatory variables, such as household income, prices and interest rates in general, affect the flow of credit and thereby housing investment.

13. Housing investment is determined as a function of starts and in general also real estate commissions plus renovations/repairs. The stock of houses usually influences the renovations/repairs component.

Appendix B

SOURCES AND METHODS USED IN THE CALCULATION OF NET STOCKS OF DWELLINGS

This Appendix describes the sources and methods used in generating the data for housing stocks used in the study. In all cases annual series for the housing stock variable, KHV, were initially calculated or derived from national sources. Semi-annual housing investment data and scrapping rates were then used to interpolate and obtain a semi-annual series for the stock of houses. All relevant data are now embodied in the Analytical Data Base (ADB) of the OECD Economics and Statistics Department.

United States

Annual series for the net stock of private dwellings are prepared by the U.S. Department of Commerce and available on the database maintained by the OECD Economic Statistics and National Accounts Division (ESNA). This series is consistent with the definition of housing investment in INTERLINK, and was interpolated to obtain a semi-annual dwelling stock series for the United States.

Japan

The net housing stock reported by the Japanese Economic Planning Agency in "Annual Report on National Accounts" (Table: "Closing Stocks of Net Fixed Assets") was used. This series is calculated in end-1980 constant prices and was converted to average 1980 constant prices using deflators reported by the same source.

Germany

The net capital stock of dwellings in 1980 constant prices is prepared by the Volkswirtschaftliche Gesamtrechnungen, Statistisches Bundesamt, and available from the OECD ESNA database. The investment data used to construct this series are not identical to the INTERLINK dwelling investment series, which is derived from the official National Accounts. The discrepancy is due to the fact that VGSB data are calculated by type of activity, whereas the National Accounts relate to the type of goods. Historically, the investment series has been about 6 per cent higher than the corresponding VGSB data. The housing stock series was therefore rescaled by 6 per cent to create a new benchmark for 1980, and the implicit rate of decay of the stock series and the housing investment series were then used to calculate an annual series for the net stock of houses forwards and backwards from this benchmark.

France

An end-1983 current price benchmark was taken from INSEE sources (an update of "Les comptes de patrimoine", INSEE, 1987). The sectoral coverage "Ménages" is virtually the same coverage as the investment series in INTERLINK ("Ménages hors entrepreneurs individuels"). This benchmark was converted to 1980 constant prises, assuming that stock prices have moved in line with the deflator for housing investment. The rescaled benchmark was then extended forwards and backwards on an annual basis using the housing investment and a rate of decay at 1.15 per cent. The 1.15 per cent is the rate used both in the DMS-4 (see INSEE, 1987) and Copain models (see Dehove, 1981).

United Kingdom

A net capital stock of houses from the ESNA database, currently supplied by the Central Statistical Office, includes publicly owned dwellings and is inconsistent with the investment series in INTERLINK, which is private sector housing investment only. An end-1980 benchmark was taken from the Central Statistical Office publication: "United Kingdom National Accounts" (Table "Net Capital stock by sector and type of asset at current replacement cost"). This current price benchmark covers the personal sector plus industrial and commercial companies, and matches the investment figures. Using the implicit price index for the CSO dwelling stock, this benchmark was corrected to average 1980 prices. The net housing stock was then calculated using the implicit rate of decay in the CSO series and housing investment in INTERLINK.

Italy

The series for the Italian stock of houses is based on a series originally calculated by Heimler and Milana (1986). This stock is a mid-year gross stock of dwellings in 1975 prices, covering the period 1953 to 1985. Using a price index also reported by Heimler and Milana, the stock series was initially converted into 1980 constant prices.

The Heimler and Milana estimates were created using former national accounts investment figures, which predate the new national accounts statistics incorporated into the INTERLINK databank. At present, the latter are only available from 1980 onwards. The revised investment series is about 1½ times higher than the old one, which has been rescaled to extend the new figures backwards. The previous data for housing investment are available in both current prices and fixed prices of 1970 in the OECD Annual National Accounts (ANA) Database, and a semi-annual series of old national accounts housing investment in constant prices of 1980 was created using the implicit price index and the rescaled semi-annual investment figures to interpolate.

A series of steps was undertaken to create a net stock of dwellings in 1980 constant prices, consistent with the new residential investment series. Heimler and Milana's stock of houses and the semi-annualised ANA series of housing investment were initially used to calculate end-period semi-annual gross stock figures and a series of discards. These discards were then rescaled to fit the new investment series. Likewise, the gross capital stock was rescaled in the second half of 1980. This benchmark, the rescaled discards and the housing investment series were then used to calculate a new gross stock of dwellings in 1980 constant prices.

In the Heimler and Milana study, the average service life was assumed to be 40 years. This information permitted the calculation of annual depreciation at 2.5 per cent of the gross stock obtained, thereby giving a series for the net housing investment. Cumulation of these net investments can be used to establish a net stock of houses once a starting point is chosen. An initial net capital stock in 1960 was used, and then modified iteratively so that -- with the successive addition of net investments -- the resulting capital stock yielded the same average growth rate over the period 1960 to 1985 as the original gross stock.

Canada

The calculation of the net stock of houses for Canada takes as a starting point the series of end-year net stock of dwellings, published by the Statistics Canada in "Fixed capital flows and stocks". The source provides the dwelling series (as well as gross capital formation and capital consumption) in both current and 1971 constant prices.

When rebased to 1981 constant prices, the reported gross capital formation does not match housing investment in INTERLINK, and a rescaling of the obtained capital stock had to take place. The reported capital consumption permitted the calculation of a series of depreciation rates, which were then used in conjunction with the residential investment series to create a capital stock consistent with these series. This was done in such a way that the average growth rate over the period 1960 to 1987 of the resulting housing stock is the same as that of the national series.

Table B

THE CALCULATION OF HOUSING STOCKS: AN OVERVIEW

	Net dwelling stock, KHV	Rate of decay, RSCRH	Comments
United States	U.S. Department of Commerce	Calculated residually	
Japan	EPA: "Annual Report on National Accounts"	Calculated residually	
Germany	Calculated	Calculated from VGSB/ ESNA series for net stock of dwellings and capital consumption	A rescaled VGSB dwelling stock is used as a benchmark in 1980
France	Calculated	Assumed equal to the figure used in DMS-4 (INSEE) and Copain (Ministère de l'Eco-nomie)	A benchmark for the dwelling stock of end-1983 is taken from an internal INSEE memorandum
United Kingdom	Calculated	Calculated from CSO series for net stock of dwellings and capital consumption	A benchmark for the dwelling stock in end-1980 is taken from CSO: "United Kingdom National Accounts"
Italy	Calculated so the average growth rate of KHV from 1960 to 1985 is equal to the average growth rate over the same period of the gross stock reported by Heimler and Milana (1986)	Calculated using the assumptions implicit in Heimler and Milana (1986)	The Heimler and Milana series for mid-year gross stock in constant prices of 1975 is rebased and rescaled to fit the INTERLINK housing investment. The series is then converted from a gross to a net stock of dwellings.
Canada	Calculated so the average growth rate of KHV from 1960 to 1987 is equal to the average growth rate over the same period of the net dwelling series reported in Statistics Canada: "Fixed capital flows and stocks"	Obtained from Statis-tics Canada: "Fixed capital flows and stocks"	

Appendix C

BRIDGING EQUATIONS FOR PCPH AND IRM

$$\Delta.\ln(PCPH/PCP) = p_1 * \Delta.\ln((PCPH/PCP)(-1)) + p_2 * \Delta.\ln((PCPH/PCP)(-2))$$

	USA	JAPAN	FRANCE	ITALY	CANADA
p_1	0.662 (6.42)	0.365 (4.07)	0.339 (2.96)	0.473 (4.79)	0.512 (4.26)
p_2			0.399 (3.49)		
Sample	61I-87II	66I-87II	64II-87II	61I-87II	62I-87II
Estimation method	OLS	OLS	OLS	OLS	OLS
SEE	0.0070	0.0082	0.0105	0.0228	0.0088
R^2 adj.	0.432	0.691	0.486	0.472	0.230
Durbin Watson	1.86	1.86	1.93	1.59	2.09
H-statistics	0.67	0.42	-0.44	1.89	-0.95

$$\Delta.IRM = i_1 * \Delta.IRL + i_2 * \Delta.IRL(-1)$$

	USA
i_1	0.576 (7.03)
i_2	0.270 (3.29)
Sample	65II-87II
Estimation method	OLS
SEE	0.325
R^2-adj.	0.724
Durbin Watson	1.91

Appendix D

SIMULATION RESULTS

Table D.1

MULTIPLIERS OF THE INTERLINK MODEL: FISCAL SHOCK

Government spending shock with fixed exchange rates and fixed short-term interest rates[1]

		USA		JAP		GER		FRA		UKM		ITA		CAN	
		I[2]	II[3]	I	II	I	II	I	II	I	II	I	II	I	II
(percentage differences from baseline)															
Real GNP/GDP[4]	80	1.3	1.5	1.1	1.1	1.0	1.1	0.7	0.6	1.0	1.0	1.0	1.0	0.9	0.9
	81	1.5	1.7	1.8	1.8	1.4	1.5	1.1	1.0	1.3	1.4	1.2	1.2	1.1	1.2
	82	1.3	1.5	2.0	2.2	1.3	1.3	1.4	1.4	1.1	1.2	1.1	1.1	1.2	1.1
	83	1.3	1.5	1.9	2.2	0.9	0.8	1.7	1.6	0.9	0.9	1.0	1.0	1.1	1.0
	84	1.3	1.5	1.5	2.0	0.8	0.8	1.9	1.8	0.8	0.8	0.9	1.0	0.8	0.8
	85	1.3	1.4	1.2	1.6	0.8	1.0	1.9	1.8	0.8	0.8	0.9	0.9	0.6	0.5
	86	1.2	1.2	0.9	1.2	0.7	1.9	1.7	0.8	0.8	0.8	0.8	0.3	0.3	0.3
	87	1.0	0.4	0.7	0.7	0.4	0.4	1.7	1.5	0.8	0.9	0.7	0.8	0.1	0.1
	88	0.6	0.4	0.4	0.1	0.4	0.3	1.5	1.3	0.8	0.9	0.7	0.8	-0.1	-0.1
	89	0.3	-0.1	0.2	-0.3	0.4	0.4	1.2	1.0	0.8	0.8	0.7	0.8	-0.2	-0.2
GNP/GDP[4] deflator	80	0.3	0.3	-0.2	-0.2	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0
	81	1.4	1.3	0.2	0.2	0.7	0.8	0.3	0.3	0.6	0.6	-0.2	-0.2	0.5	0.6
	82	2.1	2.3	1.0	1.0	1.5	1.6	0.8	0.8	1.5	1.5	-0.1	-0.1	1.3	1.3
	83	3.0	3.5	1.9	1.9	2.1	2.1	1.4	1.4	2.3	2.4	0.2	0.2	2.1	2.2
	84	4.1	4.7	2.6	2.7	2.4	2.5	2.0	2.0	2.8	2.9	0.5	0.4	3.0	3.0
	85	5.1	5.9	3.1	3.4	2.7	2.8	2.7	2.5	3.0	3.0	1.0	0.9	3.7	3.6
	86	6.0	6.8	3.4	3.9	2.8	3.0	3.1	2.9	2.8	2.8	1.3	1.3	4.0	3.9
	87	6.6	7.4	3.5	4.1	2.6	2.8	3.3	3.1	2.5	2.5	1.5	1.5	4.0	3.8
	88	6.9	7.6	3.4	4.0	2.1	2.3	3.3	3.1	2.3	2.3	1.6	1.6	3.7	3.5
	89	6.6	7.1	3.2	3.8	1.6	1.7	3.3	3.0	2.2	2.2	1.7	1.7	3.2	3.1
Real stock of houses	80		0.1		0.0		0.0		0.0		0.0		0.0		0.0
	81		0.2		0.3		0.1		0.0		0.2		0.1		0.2
	82		0.5		0.7		0.2		0.1		0.3		0.1		0.3
	83		0.8		1.4		0.3		0.2		0.4		0.2		0.4
	84		1.1		2.0		0.4		0.2		0.4		0.2		0.6
	85		1.4		2.6		0.5		0.3		0.5		0.2		0.8
	86		1.6		2.9		0.6		0.4		0.5		0.3		0.8
	87		1.7		2.9		0.7		0.4		0.6		0.3		0.8
	88		1.7		2.7		0.7		0.5		0.7		0.3		0.8
	89		1.5		2.3		0.8		0.5		0.8		0.3		0.6
Real housing investment	80	0.2	2.3	1.0	0.6	0.4	1.3	0.3	0.1	0.8	1.8	0.4	0.4	0.1	1.3
	81	0.9	4.2	2.3	2.8	1.1	2.3	1.1	0.7	1.5	4.0	1.1	0.7	1.3	1.8
	82	2.4	7.3	3.1	5.1	1.7	2.0	2.2	1.5	1.6	3.1	1.0	1.0	3.9	2.9
	83	3.0	7.1	3.3	7.9	1.6	1.5	3.3	2.0	2.0	1.9	0.4	1.1	4.6	3.6
	84	3.3	7.2	2.8	8.5	1.4	2.3	4.1	2.4	2.1	1.7	0.2	0.9	5.2	4.1
	85	3.3	6.7	2.1	7.5	1.6	3.7	4.6	2.5	2.2	1.9	0.3	0.8	4.4	2.9
	86	2.7	4.1	1.4	5.3	1.5	3.5	4.6	2.2	1.8	2.2	0.3	0.7	2.6	1.5
	87	2.5	2.5	0.7	2.6	1.2	2.8	4.2	1.8	1.2	2.5	0.0	0.5	1.1	0.4
	88	2.1	0.6	0.3	0.5	1.1	2.3	3.2	1.2	0.8	2.4	-0.5	0.4	-0.1	-0.7
	89	1.4	-2.0	0.0	-1.4	1.1	2.2	2.1	0.7	0.6	2.6	-1.1	0.2	-1.1	-1.5
Real disposable household income	80	0.7	0.6	0.8	0.8	0.6	0.6	0.3	0.3	0.5	0.6	0.4	0.4	0.6	0.6
	81	0.9	1.0	1.5	1.5	1.0	1.0	0.4	0.4	0.9	0.9	0.5	0.5	0.9	0.9
	82	0.8	0.9	1.8	1.9	1.0	1.0	0.5	0.5	0.9	0.9	0.4	0.4	0.8	0.8
	83	1.0	1.0	1.8	2.1	1.0	0.9	0.7	0.6	0.9	0.9	0.3	0.3	0.9	0.9
	84	1.1	1.2	1.7	2.1	1.1	1.1	0.8	0.7	0.9	0.9	0.2	0.2	0.8	0.8
	85	1.2	1.3	1.6	1.9	1.2	1.3	0.8	0.7	1.0	1.0	0.1	0.2	0.7	0.6
	86	1.3	1.2	1.5	1.7	1.1	1.2	0.8	0.7	1.1	1.1	0.1	0.1	0.6	0.5
	87	1.4	1.4	1.2	1.3	1.0	1.0	0.8	0.7	1.2	1.2	0.1	0.1	0.6	0.6
	88	1.3	1.2	1.0	0.9	1.0	0.9	0.7	0.6	1.3	1.3	0.0	0.0	0.5	0.5
	89	1.4	1.2	0.8	0.4	1.0	1.0	0.6	0.5	1.4	1.4	0.0	0.0	0.5	0.5

1. The shock is an increase in real government non-wage expenditure equal to 1 per cent of baseline real gross domestic product.

2. With the flow equations for housing investment described in Table 2.

3. With housing investment equations derived from the stock-adjustment equations of Table 3.

4. GNP for the United States, Japan and Germany; GDP for the United Kingdom, France, Italy and Canada.

Table D.2

MULTIPLIERS OF THE INTERLINK MODEL: MONETARY SHOCK 1

Reduction of short-term interest rates with fixed exchange rates and fixed real government expenditure[1]

		USA		JAP		GER		FRA		UKM		ITA		CAN	
		I[2]	II[3]	I	II	I	II	I	II	I	II	I	II	I	II
		(percentage differences from baseline)													
Real GNP/GDP[4]	80	0.3	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1
	81	0.8	0.7	0.5	0.4	0.4	0.5	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2
	82	1.0	1.0	0.7	0.7	0.5	0.6	0.3	0.3	0.4	0.4	0.5	0.4	0.4	0.4
	83	1.1	1.2	0.8	1.0	0.5	0.6	0.4	0.3	0.4	0.4	0.6	0.4	0.5	0.4
	84	1.0	1.1	0.8	1.1	0.5	0.6	0.5	0.4	0.4	0.4	0.7	0.6	0.5	0.4
	85	1.0	1.1	0.8	1.1	0.5	0.7	0.5	0.6	0.4	0.4	0.8	0.7	0.5	0.4
	86	1.1	1.1	0.8	1.1	0.5	0.6	0.6	0.7	0.5	0.4	0.9	0.8	0.5	0.4
	87	1.1	1.1	0.7	0.9	0.4	0.5	0.8	0.6	0.5	0.4	1.0	0.9	0.4	0.4
	88	0.9	0.7	0.7	0.8	0.4	0.5	0.9	0.7	0.5	0.5	1.1	1.0	0.4	0.4
	89	0.5	0.2	0.7	0.7	0.4	0.5	0.9	0.7	0.5	0.5	1.2	1.1	0.4	0.4
GNP/GDP[4] deflator	80	0.0	0.0	-0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	-0.1	0.0	0.0	0.0
	81	0.8	0.2	0.0	0.0	0.2	0.2	0.1	0.1	0.3	0.3	-0.1	-0.1	0.0	0.0
	82	0.8	0.7	0.2	0.2	0.6	0.6	0.2	0.2	0.6	0.7	-0.1	-0.1	0.1	0.1
	83	1.4	1.3	0.5	0.5	0.9	1.0	0.4	0.4	1.0	1.0	-0.1	-0.1	0.2	0.2
	84	1.9	1.8	0.8	0.7	1.3	1.4	0.6	0.5	1.2	1.2	-0.1	-0.1	0.4	0.3
	85	2.3	2.3	1.0	1.0	1.5	1.7	0.7	0.6	1.2	1.1	-0.2	-0.2	0.5	0.4
	86	2.7	2.8	1.0	1.2	1.6	1.8	0.8	0.7	1.0	0.9	-0.2	-0.3	0.6	0.4
	87	3.0	3.1	1.0	1.3	1.5	1.7	0.8	0.6	0.7	0.6	-0.3	-0.4	0.5	0.3
	88	3.0	3.1	0.8	1.2	1.1	1.3	0.6	0.4	0.2	0.1	-0.4	-0.5	0.4	0.1
	89	2.7	2.7	0.6	1.0	0.6	0.8	0.4	0.2	-0.2	-0.3	-0.4	-0.6	0.1	-0.1
Real stock of houses	80		0.0		0.1		0.0		0.0		0.0		0.0		0.0
	81		0.2		0.3		0.1		0.0		0.0		0.0		0.1
	82		0.4		0.6		0.1		0.1		0.1		0.0		0.2
	83		0.7		1.0		0.2		0.1		0.1		0.1		0.3
	84		1.0		1.5		0.3		0.1		0.1		0.1		0.4
	85		1.2		1.9		0.4		0.2		0.1		0.2		0.5
	86		1.4		2.3		0.5		0.2		0.0		0.2		0.6
	87		1.5		2.5		0.7		0.3		0.0		0.3		0.6
	88		1.5		2.7		0.7		0.3		0.0		0.3		0.6
	89		1.3		2.7		0.8		0.3		0.0		0.4		0.6
Real housing investment	80	3.1	1.1	1.6	1.0	0.0	0.4	0.3	0.2	0.4	0.2	0.6	0.1	0.7	0.8
	81	6.1	4.5	2.9	2.4	0.4	1.4	0.7	0.5	1.0	0.8	1.9	0.3	1.3	1.5
	82	8.2	7.9	3.3	3.7	0.8	2.0	1.3	0.8	1.4	0.6	2.9	0.6	3.2	2.4
	83	5.9	6.4	3.5	5.1	1.0	2.1	1.9	1.0	1.6	0.3	2.8	0.8	3.8	2.3
	84	4.4	5.7	3.3	6.1	0.8	2.6	2.5	1.2	1.8	0.0	2.5	0.9	4.6	2.3
	85	4.0	5.1	2.8	6.2	0.9	3.5	3.0	1.3	1.9	-0.3	2.6	1.1	4.6	2.0
	86	3.5	3.7	2.1	5.6	0.7	3.7	3.4	1.4	1.6	-0.4	3.0	1.2	3.4	1.5
	87	3.5	2.5	1.4	4.2	0.4	3.6	3.6	1.3	1.3	-0.5	3.5	1.3	2.2	0.9
	88	3.3	0.6	1.0	3.4	0.1	3.2	3.6	1.3	1.0	-0.5	3.4	1.4	2.4	0.4
	89	2.7	-1.5	0.9	2.7	-0.2	2.8	3.5	1.2	0.7	-0.6	3.1	1.5	2.5	0.0
Real disposable household income	80	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	81	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0
	82	0.3	0.4	0.4	0.4	0.3	0.3	0.1	0.1	0.0	0.0	0.2	0.1	0.1	0.0
	83	0.3	0.3	0.5	0.6	0.3	0.3	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0
	84	0.2	0.2	0.6	0.7	0.3	0.3	0.2	0.1	0.0	-0.1	0.2	0.2	-0.1	-0.1
	85	0.2	0.2	0.5	0.8	0.3	0.4	0.2	0.2	-0.1	-0.1	0.2	0.2	-0.2	-0.2
	86	0.2	0.2	0.5	0.7	0.2	0.3	0.3	0.2	-0.2	-0.2	0.3	0.2	-0.3	-0.3
	87	0.2	0.2	0.4	0.6	0.1	0.2	0.3	0.2	-0.2	-0.2	0.3	0.3	-0.4	-0.4
	88	0.0	-0.1	0.4	0.5	0.0	0.0	0.3	0.2	-0.2	-0.2	0.3	0.3	-0.5	-0.5
	89	-0.2	-0.3	0.3	0.4	-0.1	-0.1	0.3	0.3	-0.3	-0.3	0.3	0.3	-0.6	-0.6

1. The shock is a reduction of short-term interest rates by 1 percentage point relative to the baseline throughout the sample period.

2. With the flow equations for housing investment described in Table 2.

3. With housing investment equations derived from the stock-adjustment equations of Table 3.

4. GNP for the United States, Japan and Germany; GDP for the United Kingdom, France, Italy and Canada.

Table D.3

MULTIPLIERS OF THE INTERLINK MODEL: MONETARY SHOCK 2

Reduction of long-term interest rates with fixed exchange rates and fixed real government expenditure[1]

		USA		JAPAN	
		I[2]	II[3]	I[2]	II[3]
		(percentage differences from baseline)			
Real gross national product	80	0.4	0.8	0.1	0.5
	81	0.5	1.5	0.4	1.2
	82	0.5	1.4	0.6	1.7
	83	0.5	1.2	0.8	2.0
	84	0.6	1.0	0.9	1.9
	85	0.6	0.9	0.9	1.6
	86	0.6	0.7	0.9	1.4
	87	0.6	0.5	0.9	1.0
	88	0.4	0.1	1.0	0.7
	89	0.3	-0.4	1.0	0.5
Gross national product deflator	80	0.1	0.2	-0.1	-0.1
	81	0.3	0.8	0.0	0.0
	82	0.5	1.6	0.3	0.6
	83	0.6	2.2	0.5	1.3
	84	0.6	2.7	0.7	1.8
	85	0.5	3.0	0.7	2.2
	86	0.4	3.0	0.6	2.4
	87	0.3	2.7	0.4	2.2
	88	0.0	2.1	0.2	1.9
	89	-0.4	1.0	-0.1	1.4
Real stock of houses	80		0.2		0.2
	81		0.5		0.8
	82		0.9		1.7
	83		1.2		2.3
	84		1.5		3.0
	85		1.6		3.6
	86		1.6		3.9
	87		1.5		3.9
	88		1.2		3.7
	89		0.9		3.4
Real housing investment	80	-2.4	4.8	-1.6	3.0
	81	-5.0	9.9	-3.0	6.2
	82	-7.3	10.9	-3.5	7.8
	83	-5.7	7.0	-4.0	9.7
	84	-4.5	5.2	-4.4	10.2
	85	-4.4	3.3	-4.5	8.8
	86	-4.3	0.8	-4.5	6.4
	87	-4.8	-1.2	-4.0	3.6
	88	-5.1	-3.4	-4.0	1.7
	89	-5.3	-5.5	-4.2	0.3
Real disposable household income	80	0.1	0.4	0.1	0.3
	81	0.2	0.6	0.1	0.7
	82	0.1	0.4	0.3	1.1
	83	0.0	0.2	0.4	1.3
	84	0.0	0.1	0.5	1.3
	85	0.0	0.1	0.5	1.2
	86	-0.1	0.0	0.5	0.9
	87	-0.1	-0.1	0.5	0.7
	88	-0.2	-0.4	0.5	0.4
	89	-0.4	-0.6	0.5	0.2

1. The shock is a reduction of long-term interest rates by 1 percentage point relative to the baseline throughout the sample period.

2. With the flow equations for housing investment described in Table 2.

3. With housing investment equations derived from the stock-adjustment equations of Table 3.

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