DWIGHT M. JAFFEE
Princeton University

KENNETH T. ROSEN
University of California, Berkeley

Mortgage Credit Availability and Residential Construction

THE EXTRAORDINARY STRENGTH of residential construction in 1978 (2.02 million starts for the year) and the relatively small downturn in the first half of 1979 (1.75 million starts at a seasonally adjusted annual rate, including 1.92 million starts for June) has surprised many economists. Most analysts had anticipated that high interest rates on mortgages, high and rapidly rising housing prices, and slow economic growth would produce a substantial cyclical decline in housing. Various factors, however, may have been working to offset this usual cyclical scenario. The transition of the "baby boom" generation to a home-buying age and the increased appeal of home purchase for investment purposes may have raised the demand for housing. The introduction of money-market certificates (MMCs) in June 1978 for banks and thrift institutions and the increased activity (mortgage commitments and purchases and Federal Home Loan Bank advances) by secondary market agencies may have increased the availability and reduced the price of mortgage credit.

Our results indicate that the introduction of the MMCs in June 1978 is the primary reason for the strength in housing investment during 1978–79. High levels of secondary market activity by federal agencies also increased housing starts during 1978, but by relatively small amounts. Demographic factors, measured by the exceptionally high rates of house-

Note: The research for this paper was supported in part by a grant from the National Science Foundation.

0007-2303/79/0002-0333$00.25/0 © Brookings Institution

hold formation, provided an important impetus to home building, but these factors had been positive for several years, and thus do not explain the unusual cyclical strength during 1978–79. In a similar way, while the appeal of home purchase for investment purposes is high, it has not significantly accelerated in the past year. Indeed, while the data show a substantial and continuing trend toward home ownership, they provide little evidence of an acceleration in this trend since 1960, contrary to ancedotal analysis.

We first review the conventional wisdom concerning the causes of the housing cycle and recent government policy responses to that cycle. We next outline a theoretical framework of the housing, mortgage, and deposit sectors and provide a set of estimated equations. We then present a simulation analysis of each individual equation and the full set of model interactions that have occurred from 1978:3 to 1979:2. Finally, we summarize the results and the policy implications of our findings.

Historical View

Cyclical instability has been a major characteristic of the residential construction industry since World War II. During this period, seven short-term cycles have occurred in new production, on the average of one every three and a half years. The average decline (or rise) in activity, as measured by the percentage change in housing starts from peak to trough (or vice versa) has been approximately 40 percent. The decline in residential construction was especially severe in 1974–75, when the cyclical change in housing starts exceeded 80 percent. But table 1 shows that, compared with other major cycles of the postwar period, this fluctuation was really just one more episode of the longer term pattern of instability.

This extreme volatility of the housing sector and the importance of the housing cycle to macroeconomic stability has stimulated substantial research into the causes of the short-term cycle in residential construction, and has led the federal government to seek stabilizing policies. The academic research can be summarized by a quotation from one of the key studies of the housing finance system:

> The greater impact of monetary stringency on housing than on the rest of the economy apparently is due mainly to a capital rationing effect, resulting from deficiencies in current institutional arrangements for providing mortgage

Table 1. Short-Term Cycles in Residential Construction, 1953:3–1977:4[a]

Year and quarter	*Turning point in cycle*	*Number of housing units (thousands)*[b]	*Cyclical change (percent)*[c]
1953:3	Trough	1,235	32.4
1954:4	Peak	1,732	
			−49.9
1958:1	Trough	1,074	41.4
1958:4	Peak	1,647	
			−51.9
1960:4	Trough	987	48.3
1963:3	Peak	1,676	
			−59.0
1966:4	Trough	912	55.2
1969:1	Peak	1,608	
			−24.3
1970:1	Trough	1,259	65.6
1972:1	Peak	2,487	
			−88.3
1975:1	Trough	963	74.7
1977:4	Peak	2,111	

Source: See appendix.
a. The series is all privately owned housing starts, excluding mobile homes.
b. The data are seasonally adjusted at an annual rate by the authors, using X-11, method II.
c. The series is adjusted for a time trend before computing percentage changes. Percentage changes are calculated as the change in housing starts divided by the average of the values for the peak and trough.

credit, and perhaps also to an interest rate effect, reflecting a greater interest elasticity of housing demand than of demand generally.[1]

A more recent study by the Federal Reserve Board concurs with this view:

> There is general agreement that one of the primary, if not the primary, determinant of this cyclical pattern is the similar pattern that holds with respect to a critical input in the residential construction process: the supply of mortgage credit.[2]

This explanation of the short-run housing cycle in terms of mortgage availability (and to a lesser extent, mortgage cost) has had a major in-

1. Irwin Friend, "Summary and Recommendations," in Friend, dir., *Study of the Savings and Loan Industry*, submitted to the Federal Home Loan Bank Board, vol. 1 (Government Printing Office, 1970), p. 8.

2. James B. Burnham, "Private Financial Institutions and the Residential Mortgage Cycle, with Particular Reference to the Savings and Loan Industry," in Board of Governors of the Federal Reserve System, *Ways To Moderate Fluctuations in Housing Construction* (The Board, 1972), p. 81.

fluence on public policy toward housing markets. Since the late 1960s, the federal government has made a substantial effort to moderate the fluctuations in residential construction. A number of government agencies and quasi-government agencies have been initiated or redirected in the past ten years toward this end. These agencies include the Government National Mortgage Association (GNMA), the Federal National Mortgage Association (FNMA), the Federal Home Loan Mortgage Corporation (FHLMC), and the Federal Home Loan Bank Board (FHLBB). While these agencies have a number of additional functions, each has been closely involved in implementing countercyclical policies designed to stabilize the mortgage and housing markets.[3] In 1978, FNMA, FHLMC, and FHLBB showed an extraordinarily large increase in activity, adding nearly $40 billion in mortgage commitments and advances. This compares with about $20 billion added in 1977.

Until May 1978, the activities of these agencies were the prime mechanism for countercyclical policies. In June 1978, there was a substantial modification of the Regulation Q ceilings on interest rates; this change allowed thrift institutions and commercial banks to issue a new type of deposit certificate (referred to here as the MMC) with an interest rate tied to the rate on six-month Treasury bills. The certificate has a six-month life and a minimum denomination of $10,000. Until March 1979, institutions could compound interest on the certificate, and thrift institutions could pay a premium of a quarter of 1 percent over the rate allowed commercial banks. In March 1979, these certificates were modified to make them somewhat less attractive to savers. The compounding of interest was eliminated and so was the differential between thrift institutions and commercial banks when the rate on six-month Treasury bills exceeded 9 percent. These modifications were made because the large volume of money channeled into these certificates had begun to squeeze the profit margins of the thrift institutions. Additional modifications in Regulation Q ceilings were made in July 1979 to increase further the ability of institutions to pay market rates to small savers.

The modifications of Regulation Q (and the administration's proposal for a gradual but complete removal of the ceilings) are designed to enable

3. See Dwight M. Jaffee and Kenneth T. Rosen, "Estimates of the Effectiveness of Stabilization Policies for the Mortgage and Housing Markets," *Journal of Finance*, vol. 33 (June 1978), pp. 933–46.

thrift institutions to have a chance to compete for households' savings and thus to become less susceptible to the withdrawal of savings that has occurred during periods of tight money (disintermediation). This reduction in the instability of flows of deposits will, in turn, reduce the instability in the availability of credit to housing and mitigate the fluctuations in residential construction. In addition to the improvement in the efficiency of the housing finance system, the removal of ceilings on interest rates will allow the small saver to receive a more competitive return. The changes that were made in July 1979 were largely a responsive to intense lobbying pressure by consumer and other groups to improve the equity of the deposit regulations.

We will now develop the theoretical background, specification, and estimation of a small model of the housing, mortgage, and deposit sectors of the U.S. economy. There are five main estimated relationships in the model to explain the stock-level demand for home ownership, single-family housing starts, multifamily housing starts, the interest rate on mortgages, and the deposit flows of thrift institutions. The model has been kept small, particularly in the reduced-form treatment of the mortgage sector, so that it would be manageable and readily understandable in a paper of this length. Reported in a later section are simulation experiments with the model, which relate to the effects on housing market activity of MMCs and the activity of federal agencies in the mortgage market.

The equations were estimated using quarterly data, beginning with the earliest period allowed by the data for each equation and ending in 1978:2. Single-equation simulations are provided below (with dynamic feedback for lagged dependent variables) for each equation from 1978:3 to 1979:2 to test for changes in behavior during this period.

Housing Markets

We begin with a theory and three equations for the housing sector of the model. Recent surveys of models of the housing sector indicate that, while a set of common variables is often used, no single or uniform econometric specification is widely accepted.[4] As a result, it is important to develop first the theoretical structure of the model of the housing, mortgage, and deposit sectors that we intend to estimate and simulate.

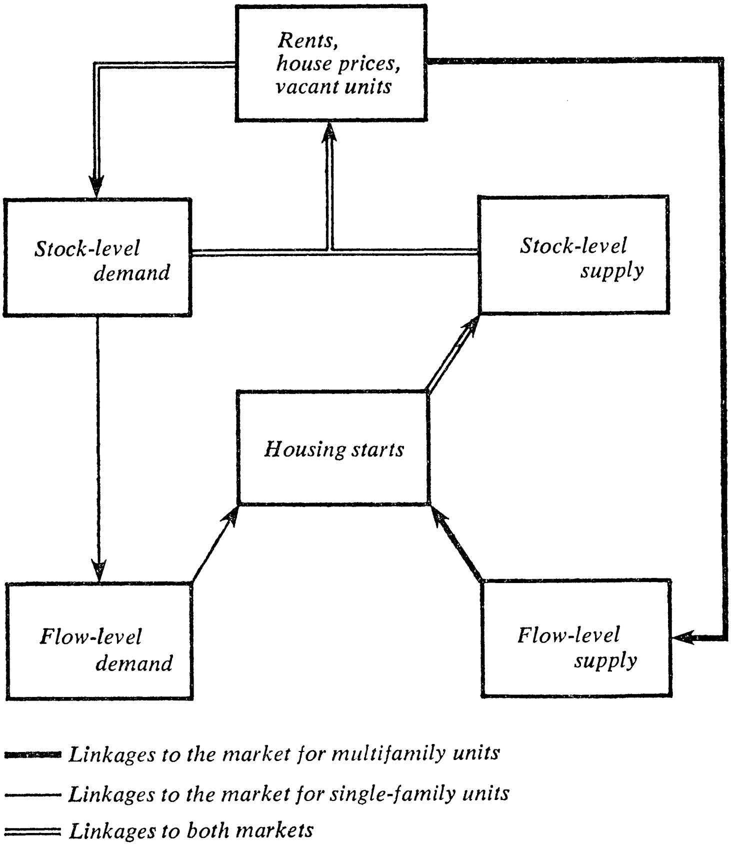
A measurement problem arises at the outset because housing can be measured as either the number of units or as the real value of the units. A major advantage of focusing on the former is the existence of accounting identities that can be derived for households, housing starts, vacant units, and existing stocks. A major disadvantage is that quality changes in the housing stock are disregarded. Given the difficulty in adjusting house prices for quality over time and the advantages of integrating the demographic analysis, we have chosen to focus our analysis on the number of units demanded and supplied.

Our overall theoretical structure for the housing market distinguishes stock-level and flow-level decisionmaking and emphasizes special features of the equations for single-family and multifamily housing starts. Figure 1 provides a flow diagram of the internal structure of this housing model. As shown, the model fits a Marshallian demand-supply structure, but with some complexity because of the interrelationships of stocks and flows, and the special feature of the single-family and multifamily submarkets.

The demand function for the stock concerns decisions on household formation as the first step and decisions on tenure choice (whether to own or rent) as the second step. The supply function for the stock is based on perpetual inventory principles with the current stock determined as the sum of newly constructed units and the existing stock surviving from the preceding period. The number of vacant units is then defined as the stock supply minus demand. Rents and house prices are also determined by this stock-level, demand-supply balance.

4. See Gary Fromm, "Econometric Models of the Residential Construction Sector: A Comparison," in R. Bruce Ricks, ed., *National Housing Models: Application of Econometric Techniques to Problems of Housing Research* (Lexington, 1973), pp. 125–34; Martin S. Geisel, "Housing and Residential Construction: A Survey of Econometric Studies" (Carnegie-Mellon University, Graduate School of Industrial Administration, September 1972); Leo Grebler and Sherman J. Maisel, "Determinants of Residential Construction: A Review of Present Knowledge," in Daniel B. Suits and others, *Impacts of Monetary Policy,* prepared for the Commission on Money and Credit (Prentice-Hall, 1963), pp. 475–620; and James Kearl, Kenneth Rosen, and Craig Swan, "Relationships Between the Mortgage Instruments, the Demand for Housing and Mortgage Credit: A Review of Empirical Studies," in Franco Modigliani and Donald Lessard, eds., *New Mortgage Designs for Stable Housing in an Inflationary Environment,* Conference Series, 14 (Federal Reserve Bank of Boston, 1975), pp. 93–109.

Figure 1. Internal Structure of the Model for the Housing Market[a]



a. Not shown are exogenous forces from demographic factors, capital markets, and the macroeconomy.

Housing starts are determined as the result of decisions on flows. In principle, these decisions arise from both demand and supply factors. In fact, however, institutional considerations indicate that only one side of the market reflects active behavioral decisions. The demand side determines housing starts in the market for single-family units, while the supply side determines starts in the market for multifamily units.

Single-family housing starts are determined by demand in the model because the majority of single-family units are now custom-built, self-built, or directly contracted in some other manner. The supply of single-family starts is, moreover, well approximated by an infinitely elastic schedule.[5] Indeed, for this reason, construction resources flow rapidly into and out of this sector, corresponding to fluctuations in demand, while vacancy rates are low and stable.

Multifamily housing starts are determined by supply in the model, reflecting the profit opportunities of developer-construction firms. Demand factors influence multifamily housing starts through stock-level forces, whereby potential renters signal their demand by bidding up rents and eliminating vacant units. Multifamily housing starts are then determined by the response of the construction industry to these signals. Flow-level demand forces would operate directly in this market only if the potential occupants ordered their units. This clearly is not the case for rental apartments, and even multifamily condominium units typically are built speculatively without orders before production.

STOCK-LEVEL DEMAND

Our starting point is the demographic demand for housing units. It is derived from the total population, from its age distribution, and from the way in which the population groups itself into household units. For any short- or medium-term national analysis, both the population and its age distribution are known with a high degree of precision. The translation of the age distribution of the population into housing demand, while subject to uncertainty resulting from the forces that influence household formation, is still fairly predictable in the short run.

Specifically, the impact of the baby boom on the housing and other markets could have been generally anticipated by an analysis that included demographic factors. Table 2 shows the startling but highly predictable changes in the age distribution that occurred in the 1970s. The dramatic increase in the population aged 18 to 34 has led (and will continue to lead) to a large increase in housing demand; in particular, as people move into the group aged 25 to 34, they raise the demand for housing for owner-occupancy.

Not only has the population in the age group of the "first housing unit"

5. See Craig Swan, "Labor and Material Requirements for Housing," *BPEA, 2:1971*, pp. 347–77; and William E. Gibson, "Protecting Homebuilding from Restrictive Credit Conditions," *BPEA, 3:1973*, pp. 647–91.

Table 2. Change in the Age Distribution of the Population, 1970–78

	Population (thousands)		*Change, 1970–78*	
Age group	*April 1, 1970*	*July 1, 1978*	*Number (thousands)*	*Percent*
All ages	204,335	218,548	14,213	7.0
Under 5	17,163	15,361	−1,801	−10.5
5–13	36,675	31,378	−5,297	−14.4
14–17	15,854	16,639	785	4.9
18–24	24,455	28,944	4,489	18.4
25–34	25,146	33,936	8,791	35.0
35–44	23,214	24,383	1,170	5.0
45–54	23,254	23,184	−70	−0.3
55–64	18,603	20,668	2,066	11.1
65 and over	19,972	24,054	4,082	20.4

Source: U.S. Bureau of the Census, *Current Population Reports*, series P-20, no. 336, "Population Profile of the United States: 1978" (Government Printing Office, 1979), table 6.

category grown dramatically, but, more generally, the propensity of the population to group itself into housing units has expanded greatly. The link between population and housing units is the "household," defined by the U.S. Bureau of the Census as a group of individuals residing in shared living quarters. Thus the total number of households, technically "primary" households, is identical in concept to the total number of occupied housing units. The formal accounting translation from population to households is the "headship" rate, defined as the ratio of the number of households to the corresponding population aggregate. Rising headship rates thus indicate a demand for housing that is expanding beyond the levels based on population growth alone.

Table 3 shows the headship rates for four age categories, and it can be seen that the rate for each age category grows significantly during the period. Most important, between 1960 and 1978, the headship rate for ages 25 to 34 grows by over 7 percentage points, and for ages under 25 by almost 5 percentage points.

These rising headship rates are interesting phenomena. Hickman developed a model that explains the change in aggregate households as a function of the age structure and size of the population and of real income growth. Maisel analyzed the 1950s data with a model that focuses on the

Table 3. Headship Rates, by Age of Head of Household, 1960–78[a]
Proportion

	Age of head			
Year	*Under 25*	*25–34*	*35–64*	*Over 64*
1960	0.106	0.429	0.516	0.565
1961	0.106	0.435	0.519	0.558
1962	0.110	0.440	0.515	0.590
1963	0.104	0.439	0.517	0.591
1964	0.107	0.440	0.521	0.586
1965	0.113	0.448	0.524	0.594
1966	0.114	0.450	0.526	0.601
1967	0.112	0.457	0.527	0.601
1968	0.117	0.452	0.535	0.613
1969	0.120	0.468	0.536	0.615
1970	0.122	0.471	0.538	0.615
1971	0.128	0.469	0.543	0.620
1972	0.138	0.473	0.540	0.634
1973	0.143	0.480	0.543	0.631
1974	0.150	0.487	0.542	0.636
1975	0.147	0.489	0.544	0.636
1976	0.146	0.489	0.550	0.645
1977	0.147	0.493	0.553	0.630
1978	0.152	0.501	0.554	0.633

Sources: Bureau of the Census, *Current Population Reports,* series P-20, *Population Characteristics* and P-25, *Population Estimates and Projections,* various issues.
a. The headship rate is the ratio of the number of heads of households in an age group to the corresponding population aggregate.

number of marriages and the relationship of the marriage rate to the unemployment rate.[6]

Another key factor in the rise of headship rates is that large numbers of people have opted, because of economic and sociological forces, to form primary individual households when they previously would have been submembers of family households. These primary individual households result from young persons setting up their own households, delaying mar-

6. See Bert G. Hickman, "What Became of the Building Cycle?" in Paul A. David and Melvin W. Reder, eds., *Nations and Households in Economic Growth, Essays in Honor of Moses Abramovitz* (Academic Press, 1974), pp. 291–314; and Sherman J. Maisel, "Changes in the Rate and Components of Household Formation," *Journal of the American Statistical Association,* vol. 55 (June 1960), pp. 268–83. Incidentally, Maisel notes an "Okun's law" of household formation: "that for short-run fluctuations, about a three per cent decrease in the number of marriages occurs for each one per cent increase in unemployment" (p. 274).

Table 4. Owner-Occupancy Rates, by Age of Head and Type of Household, 1970[a]
Proportion

Age of head of household	*Primary family households*	*Primary individual households*
Under 25	0.251	0.068
25–34	0.542	0.135
35–64	0.766	0.426
65 and over	0.775	0.555

Source: Bureau of the Census, *Census of Population, 1970, Subject Reports,* Final Report PC (2)-4A, *Family Composition* (GPO, 1973), table 1.
a. The owner-occupancy rate is the proportion of households that reside in owner-occupied units.

riage, or living with a person of the opposite sex, as well as from the dissolution of existing households by divorce and the preference of surviving elderly spouses to retain their own independent living quarters.

A shift in the tenure choices of households—that is, between owning and renting—has accompanied the overall growth in household formation and housing demand. Tenure choice is a fundamental decision on the demand side of the housing market and is influenced by a combination of demographic and economic factors. For example, the propensity toward home ownership for both family and individual households appears to follow a life-cycle pattern. Young households, who tend to have higher mobility rates, less secure job prospects, lower incomes, and a smaller amount of wealth, tend to rent housing units. As household heads reach the age of thirty, geographic mobility declines, job prospects and family relationships become more secure, real income rises, and wealth tends to be accumulated. As a result, by the age of thirty-five, the majority of heads of family households and a substantial minority of individual household heads have chosen to own housing units. As table 4 shows, 77 percent of family heads aged 35 to 64 own their housing unit as compared to 25 percent under 25 years of age and 54 percent aged 25 to 34.

These basic demographic tendencies are complemented by a set of economic determinants of tenure choice. In particular, the cost of home ownership relative to the cost of renting a housing unit is a crucial factor influencing the demand for housing for owner occupancy. The cost of owning a home is dependent on the purchase price of a home, the interest rate on the mortgage loan that most households utilize to purchase the home, the annual property tax, and expenditures for maintenance and repair. Two additional elements that have become increasingly important in recent years and reduce the cost of home ownership are the potential deductibility, for federal income tax purposes, of property tax and mortgage interest payments and the expected appreciation in the value of the housing unit. Rosen and Rosen provide a detailed discussion of the measurement of the housing cost of capital and its influence on home ownership.[7]

An additional factor determining the demand for housing for owner occupancy is the real permanent income of households. Households with higher income tend to have a greater demand for space and social privacy, which are normally associated with owner-occupied units. In addition, the advantage of the explicit and implicit tax subsidies to home ownership makes this tenure choice more desirable for high-income households.

A final short-run determinant is the availability of mortgage credit. During periods of credit tightness the inability of the household to obtain a mortgage loan at the prevailing interest rate on mortgages can drastically reduce the incremental demand for housing for owner occupancy. The measurement of the availability of mortgage credit and its determination in the model is discussed in detail below.

The Demand for Housing

The discussion has indicated that housing-demand decisions occur on two levels: first, the decision concerning household formation, and second, the tenure choice—to own or rent. In this paper we use the data on household formation by age and type, but treat it as exogenously given.[8] We focus on the tenure choice. Data on owner-occupancy rates (the proportion of total households that reside in owner-occupied units) are available from the quarterly Housing Vacancy Survey of the Bureau of the Census. Table 5 presents the data. The owner-occupancy rates, shown in column 1, indicate a steady, but moderate, upward trend, with the aggregate rate rising from 62 percent in 1960 to 65 percent in 1978. Specifi-

7. See Harvey Rosen and Kenneth Rosen, "Federal Taxes and Homeownership: Evidence from Time Series," *Journal of Political Economy*, vol. 88 (forthcoming in 1980).

8. In fact, we are currently engaged in a project that will estimate equations to explain household formation, with disaggregation by age of head and type. We suspect that the omission of endogenous equations for household formation from the model will have relatively minor consequences for the four-quarter time span of our simulation.

Table 5. Trends in Owner-Occupied Units, 1960–78

		Owner-occupied units (thousands)		
Year	Owner-occupancy rate (proportion) (1)	Number (2)	Adjusted number[a] (3)	Ratio of actual to adjusted number (4)
1960	0.621	32,909	35,068	0.938
1961	0.624	33,612	35,679	0.942
1962	0.630	34,578	36,273	0.953
1963	0.631	35,018	36,774	0.952
1964	0.631	35,636	37,286	0.956
1965	0.633	36,510	37,802	0.966
1966	0.634	37,158	38,330	0.969
1967	0.636	37,925	38,985	0.973
1968	0.639	39,083	39,722	0.984
1969	0.643	40,193	40,318	0.997
1970	0.642	40,920	40,940	1.000
1971	0.642	41,944	41,654	1.007
1972	0.644	43,231	42,404	1.020
1973	0.645	44,333	43,128	1.028
1974	0.646	45,385	43,739	1.038
1975	0.646	46,212	44,437	1.040
1976	0.647	47,423	45,199	1.049
1977	0.648	48,341	45,776	1.056
1978	0.650	49,726	46,550	1.068

Sources: For owner-occupancy rates and the number of owner-occupied units, see the appendix. The number of owner-occupied units equals the occupancy rate times the number of households. The adjusted number of owner-occupied units is derived from the number of owner-occupied units and the data in table 4, as described in the text.

a. The adjusted series reflects 1970 owner-occupancy proportions of eight household categories, as described in the text.

cally, these data show an average annual increase of 0.2 percentage point between 1960 and 1970, and 0.1 percentage point between 1970 and 1978.[9]

The basically steady—and, if anything, decelerating—trend of owner-occupancy rates during the 1970s stands in strong contrast to popular dis-

9. The Annual Housing Survey (AHS) provides an alternative source of owner-occupancy rates, currently available for the years 1973 to 1976; its results are close to those of the Housing Vacancy Survey (HVS), not surprisingly since both are based on sampling procedures similar to those of the Current Population Survey. Neither the AHS nor the HVS data provide evidence of an accelerating trend in owner-occupancy rates since 1971. The decennial Census of Population, a third source of data for owner-occupancy rates, comes close to the HVS values for 1960, but is considerably lower for 1970 (0.633 versus 0.642).

cussions and anecdotal evidence of a "surge toward home ownership." Two major factors bridge the difference between our data and this view. First, the data used here refer to the number of units, not the value of units. Any trend toward larger or higher quality owner-occupied homes would not be reflected in our data. Second, an increase in the number of second homes would not raise our measure of home ownership. The second home would not affect the owner-occupancy rate if it were unoccupied and would actually lower the rate if it were rented (and hence renter-occupied).

Changes in the underlying demographic patterns may complicate the interpretation of trends in owner occupancy. For one thing, household formation has accelerated in the 1970s, leading to a larger absolute increase in the number of owner-occupied units, from an annual average of 800,000 between 1960 and 1970, to 1.1 million between 1970 and 1978. Moreover, in any analysis of demographic patterns, the composition of households by the age of the head and by type (family or individual) must be taken into account. We therefore constructed a series on owner occupancy that controls for the changing distribution of the age and type categories. The *HADJ* series, shown in column 3 of table 5, records how the total number of owner-occupied units would have grown if the rate of owner occupancy by each type of household had remained constant. Specifically, this hypothetical calculation assumes that the owner-occupancy rates of the eight household categories shown in table 4 is identical throughout the period to their actual values in 1970.[10] Thus in 1970, *HADJ* equals, by construction, the actual number of owner-occupied units, *HOWN* (column 2), apart from a rounding error. Deviations between the two series in other years then reflect changes in the actual owner-occupancy propensities within the various household categories, because these changing propensities are omitted from *HADJ* and included in *HOWN*.

The ratio of *HOWN* to *HADJ*, column 4, thus reveals those changes in owner-occupancy rates left after correction for purely demographic shifts. The ratio rises quite sharply, from a value of 0.94 in 1960 to almost 1.07 in 1978, a much faster pace than the change in the aggregate owner-occupancy rate shown in column 1. In other words, if the age- and type-specific occupancy rates of 1970 had been maintained, there would have been 3.2 million fewer owner-occupied units in 1978. Indeed, the overall

10. In the equations below, quarterly values for *HADJ* had to be interpolated; the number of marriages on a quarterly basis were used for the weights.

owner-occupancy rate would then have declined, reflecting the shift in the distribution of households toward those age and type categories that have below-average propensities to own homes. The rapid increase in the ratio of *HOWN* to *HADJ* confirms the presence of a trend toward home ownership. But that trend did not accelerate between the 1960s and the 1970s. Thus in estimating equations for home ownership and single-family housing starts, we are more cautious about attributing any major role to financial investment incentives than the conventional view would suggest.

The estimated equation for the stock-level demand for owner-occupied units is based on the following stock adjustment:

$$\Delta HOWN = g[(a_0 + a_1X)HADJ - HOWN_{-1}], \tag{1}$$

where *HOWN* is the number of owner-occupied units and *HADJ* is the adjusted number of units (annual values shown in columns 2 and 3 of table 5); and X is a vector of economic variables that affect the owner-occupancy rate over time. In the equation, $(a_0 + a_1X)$ *HADJ* is viewed as the long-run demand for owner-occupied units; $HOWN_{-1}$ is the number of existing owner-occupied units; and *HOWN* gradually adjusts to match the long-run demand.

Three economic variables are specified for X following the discussion above. First, the ratio of home ownership costs to rental costs is measured by the ratio of the home ownership component to the rental price component of the consumer price index, *CPIO/CPIR*. As this ratio increases, we would expect a decline in owner-occupancy rates. Second, the unemployment rate, *UR*, is also expected to have a negative impact on owner occupancy. The third variable is a measure of mortgage availability, the real value (deflated by housing prices) of deposit flows to thrift institutions, $\Delta DEP/PH$. It should have a positive impact on owner occupancy. The choice of this measure for the availability of mortgage credit is discussed in detail below. Tests were also carried out on a variable measuring the availability of mortgage credit from federal agencies, but it did not enter the specification significantly. These economic variables are scaled multiplicatively by HADJ.[11]

11. A more detailed description of the data is provided in the appendix. Here, and in subsequent equations, interest rates are measured in percentage points; housing and demographic variables, in thousands of units; and nominal values, in billions of dollars, except as noted. Seasonal dummies are included (but not shown) for each equation because many of the series are not seasonally adjusted. All equations were estimated by the ordinary least squares technique, using the Hildreth-Lu scan for the

The equation, estimated for the period from 1964:1 to 1978:2, is

$$(2)\quad \Delta HOWN = \underset{}{\text{constant}} + \underset{(6.6)}{0.88HADJ} - \underset{(-2.1)}{0.001(UR)HADJ}$$

$$- \underset{(-2.2)}{0.01}[(CPIO_{-2}/CPIR_{-2}) + (CPIO_{-3}/CPIR_{-3})]HADJ$$

$$+ \underset{(1.9)}{3.3}(\Delta DEP_{-1}/PH_{-2})HADJ - \underset{(-6.4)}{0.50(HOWN_{-1})},$$

$R^2 = 0.813$; Durbin-Watson = 1.65; percentage standard error = 9.94; rho = 0.95.

The estimated autocorrelation coefficient is 0.95; the high value may reflect the quarterly construction of the *HOWN* and *HADJ* data. Otherwise, the equation fits well and the coefficients are statistically significant. The speed of adjustment, corresponding to the parameter g in equation 1, is 50 percent a quarter. Consequently, the long-run response of *HOWN* to changes in *HADJ* (corresponding to coefficient a_0 in 1) is 1.76. We expected this coefficient to be on the order of 1.0, and find the larger value disturbing because the equation seems to fit the rising rates of owner occupancy through this mechanism. We also tested variables such as the expected price appreciation of owner-occupied houses, various tax effects, and other factors relating to the investment returns to owner occupancy, but, consistent with the discussion of trends in owner-occupancy rates, none of these variables was significant. Finally, the three economic variables in equation 2 corresponding to the X vector in 1 have the correct signs and are statistically significant. However, the magnitude of the effect of these variables on owner-occupancy rates is quite limited.

SINGLE-FAMILY HOUSING STARTS

Our specification of the equation for single-family housing starts combines the work of Muth on stock-adjustment models of housing demand,[12]

---

first-order autoregressive coefficient. The t-statistics are shown in parentheses below the respective coefficients. Either the standard error or the percentage standard error (the standard error as a percent of the mean of the dependent variable) is presented, as indicated.

12. See Richard F. Muth, "The Demand for Non-Farm Housing," in Arnold C. Harberger, ed., *The Demand for Durable Goods* (University of Chicago Press, 1960), pp. 27–96.

the results of the previous section on the stock-level demand for owner-occupied units, and the effect of credit-availability factors that influence the exact cyclical timing of housing starts. The basic specification can be written as

$$(3)\quad SSF = b_0 + b_1(\Delta HOSF) + b_2(KSF_{-1}) + b_3(VUSF_{-1}) + b_4(AVAIL),$$

where

SSF = number of single-family housing starts
HOSF = number of occupied single-family units
KSF = number of existing single-family units
$VUSF$ = number of vacant single-family units
$AVAIL$ = vector of variables representing mortgage cost and credit availability.

Each of the first three variables reflects a component of the demand for single-family units. The first is the net change in the number of occupied single-family units, and thus directly reflects the net increment to demand. The second is a proxy for the part of production that replaces depreciated, removed, or converted units; the specification assumes that such replacement demand is proportional to the outstanding stock of units. The third variable stands for the part of production necessary to bring the number of vacant units into line with the desired level.

Two modifications were required in the actual fitting procedure for these three variables. First, the number of owner-occupied units, *HOWN,* replaced the number of occupied single-family units, *HOSF,* because quarterly data on the latter are not available. Little bias should occur in this substitution because about 95 percent of owner-occupied units are single-family units. Second, multicollinearity between *HOWN* and our measure of *VUSF* precluded a statistically significant coefficient for the latter, and it was dropped in the final equation.

In principle, these effects of the cost and availability of mortgage credit, *AVAIL,* should be already included in the *HOSF* term (or *HOWN,* as it is actually estimated). However, as the discussion in the preceding section indicated, only modest effects of credit availability appear in the *HOWN* equation. In contrast, we expect—and at least want to test for—a more significant impact of mortgage cost and availability on the timing of housing starts. The significant role that we do find for the mortgage variables in the housing-start equation (see below) thus indicates an inadequacy in the *HOWN* series for measuring short-run variations in effective housing demand. In retrospect, it is not surprising that the housing-start series yields more information relating to short-run fluctuations because the data are explicitly in the flow dimension and are actually collected on a monthly basis. The *HOWN* series, in contrast, concerns stock-level decisions on tenure choice, and is derived from a quarterly sample of survey responses.

The specific series used for the cost of mortgage credit is the nominal interest rate on mortgages, *RM*. Tests were carried out with various measures of real mortgage rates, but the expected inflation (or appreciation) components were not statistically significant, again in line with the discussion above of trends in home ownership. The use of the nominal interest rate on mortgages by itself is also reasonable because this rate determines in part the size of the monthly mortgage payment. Particularly in an inflationary setting, high monthly payments may present cash-flow problems that reduce housing demand. The effects of mortgage availability were measured by two variables: the flow of deposits into thrift institutions, ΔDEP, deflated by housing prices, *PH;* and a measure of the flow of mortgage credit from federal agencies, *FAC*, which is also deflated by housing prices.[13] The choice of these variables to measure mortgage availability is discussed in detail below.

The equation for single-family housing starts, estimated for the period from 1965:2 to 1978:2, is[14]

$$(4)\quad SSF = constant + \underset{(1.6)}{0.25}\Delta HOWN + \underset{(2.2)}{0.02}KSF_{-1} - \underset{(-1.9)}{0.001}(RM)KSF_{-1} + \underset{(2.1)}{1.35}\left(\frac{\Delta DEP}{PH}\right)KSF_{-1} + \underset{(1.4)}{1.16}\left(\frac{FAC}{PH}\right)KSF_{-1},$$

$R^2 = 0.947$; Durbin-Watson $= 1.97$; percentage standard error $= 7.37$, rho $= 0.80$.

The equation fits well, with a standard error of a little more than 7 percent. While all coefficients have the expected sign, several are on the bor-

13. The variable *FAC* is the sum of new mortgage commitments made by the Government National Mortgage Association, the Federal National Mortgage Association, and the Federal Home Loan Mortgage Corporation, and the net change in Federal Home Loan Bank advances.

14. The $\Delta HOWN$ series is a four-quarter average; the $\Delta DEP/PH$ and FAC/PH terms are three- and two-quarter averages, respectively; and KSF_{-1} is a multiplicative scaling factor.

derline of statistical significance. Apparently this is the result of collinearity with the variable for federal agency credit, because when it is omitted from the specification, the R^2 changes very little and all the remaining variables have t-statistics greater than 2.0. Alternatively, the last two variables of the equation can be combined in a single term, and then again the t-statistics for all coefficients are above 2.0. We use the equation presented above in the simulation experiments because it should provide the best estimates of the various terms, t-statistics notwithstanding.

The magnitudes of the coefficients in general are reasonable. The coefficient on $\Delta HOWN$ is somewhat low because it implies that only 25 percent of the change in the demand for owner-occupied units is reflected in single-family housing starts.[15] The mortgage interest-rate term implies that an increase of 1 percentage point in interest rates on mortgages reduces housing starts by about 140,000 units at annual rates. The deposit-flow term implies that a \$1 billion increase in annual deposit flows increases housing starts by about 15,000 units at annual rates.[16] A similar increase in the flow of federal agency credit would increase housing starts by about 8,000 units at annual rates.[17]

MULTIFAMILY HOUSING STARTS

Our specification of the equation for multifamily starts, *SMF*, emphasizes flow-level, supply-side factors. Specifically, five factors enter our specification of the supply-side incentives to undertake multifamily housing starts.

Profit Margins. Profit margins of the multifamily construction industry should be a primary force determining multifamily housing starts. The ideal variable would compare the discounted value of anticipated net rental income with the construction cost. Unfortunately, no available data accurately measure either concept. For rental income we used the rental component of the consumer price index, *CPIR*. For the construction cost

15. The coefficient of the *KSF* variable cannot be interpreted as a depreciation rate since *KSF* also serves as the multiplicative scaling of several other variables in the estimated equation.

16. Note that 15,000 units evaluated at \$60,000 each equals \$900 million, which is fully consistent with a \$1 billion deposit inflow.

17. Federal agency credit is less effective than deposit flows as a stimulus to housing starts, mainly because our measure of agency credit is based on commitments issued by the agencies, and a significant fraction of these commitments expire unused.

we experimented with available indexes of construction cost, but—not surprisingly, in view of the well-known problems with these series—it was found that the overall consumer price index, CPIT, was a more successful variable. Thus the profit margin variable is measured here as *CPIR/CPIT*.

Mortgage Interest Rate. An interest-rate variable should enter with a negative effect in the specification for two reasons. First, as indicated above, rental income should be discounted to the present as an element of the profit-margin variable. Second, profitability is affected by the cost of funds (construction loans) over the long period that it takes to complete multifamily construction projects. The investor in such a project is thus critically sensitive to the mortgage rate. The term is specified as a real rate: the nominal rate minus overall inflation, $RM - DCPIT$, where *DCPIT* is the annual percentage rate of change in *CPIT*.

Multifamily Vacancy Rates. Vacancy rates, *VR,* enter the specification as a disequilibrium component in which a saturated market with high vacancy rates tends to depress multifamily housing starts, as marginal rental prices then fall below the quoted rental rates.

Mortgage Fund Rationing. Although rationing effects on mortgage funds are often associated primarily with single-family housing starts, it is also reasonable to test for such effects on multifamily starts. The situation is complicated, however, because financing multifamily projects is generally a two-stage process—first construction loans and later long-term financing—and because a wide variety of sources are used for both levels of financing. Thrift institutions have become the most important source of funds in this market, representing about 20 percent of the short-term financing and about 40 percent of the long-term financing of multifamily projects in recent years. Thus the rationing variable used here is the real flow of funds to thrift institutions, $\Delta DEP/CPIT$.

Outstanding Stock of Multifamily Units. The size of the outstanding stock, *KMF,* serves as the scaling (multiplicative) element for each of the explanatory variables listed above. Consequently, the variable should also enter the specification directly.

The long production time necessary for construction of multifamily housing should be expected to produce relatively long lags in the effect of the first four variables. Experiments were carried out with polynomial distributed lags for each variable, but multicollinearity made some of the results difficult to interpret. Consequently, simple arithmetic averages were used for each of the variables. The longest lags were found for the variables representing the vacancy rate, *VR,* and profit margin, *CPIR/CPIT* (four and three quarters, respectively), suggesting that these factors are taken into account early in the planning period. Shorter, two-period lags were found for the variables representing mortgage interest rate, $RM - DCPIT$, and availability of mortgage credit, $\Delta DEP/CPIT$, suggesting that financial constraints come into play closer to the actual date of beginning construction.

The equation, estimated for the period from 1964:1 to 1978:2, provided the following results:

$$\begin{aligned}
(5)\quad SMF = {} & constant + \underset{(3.0)}{0.02}(CPIR/CPIT)KMF_{-1} \\
& - \underset{(-2.5)}{0.001}(RM - DCPIT)KMF_{-1} - \underset{(-3.8)}{0.001}(VR)KMF_{-1} \\
& + \underset{(3.9)}{0.02}(\Delta DEP/CPIT)KMF_{-1} - \underset{(-1.8)}{0.02}KMF_{-1},
\end{aligned}$$

$R^2 = 0.944$; Durbin-Watson $= 2.36$; percentage standard error $= 10.54$; rho $= 0.80$.

The equation fits well; all coefficients have the expected sign and are statistically significant. Variables representing new mortgage commitments of federal agencies and those for subsidized units under programs administered by the U.S. Department of Housing and Urban Development were also tested but did not enter the specification significantly.

The magnitudes of the coefficients imply large effects from changes in each of the key explanatory variables. For example, an increase of 1 percentage point in the vacancy rate and the interest rate on mortgages will depress housing starts at annual rates by 200,000 and 100,000 units, respectively. An increase of 10 percent in real rental prices raises annual housing starts by over 200,000 units, while an increase of $1 billion in deposit flows raises them by 16,000 units.

Mortgage and Deposit Markets

The cost and availability of mortgage credit clearly play a critical role in the model of activity in the housing market presented above. In this section we focus on the determinants of the interest rate on mortgages, as the measure of the cost of mortgage credit, and on deposit flows to thrift institutions, which together with mortgage credit provided by federal agencies is the measure of mortgage availability. Because Regulation Q ceilings may influence both the cost and availability of mortgage credit, and particularly because the two paths of influence lead to offsetting effects on housing starts, we also analyze these interconnections.

AVAILABILITY AND COST OF MORTGAGES

Modeling the mortgage market on a structural level poses immediate problems because both demand and supply are derived relationships with relatively rigid ratios linking the mortgage schedules to the underlying markets. On the supply side, depository institutions, particularly thrift institutions, are the predominant force in the market. The supply of mortgage funds thus moves in step with the flow of deposit funds—especially for savings and loan associations, which supply about 50 percent of mortgages for single-family homes.[18] On the demand side, most borrowers find mortgage credit necessary to finance their home purchase, and they seek the largest loan available based on their collateral. Thus mortgage demand is tied quite directly to the demand for housing.

In a framework of demand-supply equilibrium for the mortgage market, changes in interest rates on mortgages would be generated by fluctuations in the underlying markets, specifically housing activity on the demand side and deposit flows on the supply side. Because housing activity and deposit flows themselves fluctuate a great deal, one would expect rather strong movements in the interest rates on mortgages compared with interest rates on other capital-market instruments of similar maturity. In fact, however, interest rates on mortgages are sluggish, moving more slowly than most other interest rates in the capital markets. This behavior could be the result of stabilizing interventions by federal agencies, but sluggish movements in interest rates on mortgages have been evident in the United States at least since the beginning of this century, long before the federal agencies existed. Rather, institutional and structural factors appear to be the primary explanation; usury ceilings, for example, place ceilings on levels of mortgage rates (and, it appears, floors also) in a number of areas. Search theory suggests a more fundamental explanation in

18. Recent innovations in the mortgage market, particularly the issue of mortgage-backed bonds, pass-through securities, and secondary market sales of mortgage assets have weakened the link between deposit flows and mortgage originations for thrift institutions. This "unbundling" of mortgage origination and mortgage-portfolio activities by thrift institutions is on our agenda for further research.

terms of price determination in overlapping local markets with elements of monopolistic competition. And political considerations are evident, with mortgage borrowers representing a potent force, not only in the United States but also in many European countries.

The sluggish changes in interest rates on mortgages are evidence of a disequilibrium element in the mortgage market. When this interest rate does not rise rapidly in the presence of excess demand in the mortgage market, nonprice rationing must be used to allocate the supply. The form of this rationing varies, depending on a variety of factors. In extreme cases, there are "bare-shelf" conditions in which mortgage loans are basically not available on any terms or at any price. More commonly, variations in nonprice terms associated with mortgage loans play a role. For example, reductions in loan-to-value ratios are common in such periods; they serve to ration credit both by reducing the amount loaned to actual borrowers and by eliminating some would-be borrowers who require loans with low down-payments. Variations in maturities, prepayment penalties, and other nonprice terms can operate in a similar way.

The measurement of mortgage availability poses a continuing problem. The approach followed here uses deposit flows to thrift institutions as the endogenous market measure of availability. Mortgage credit available from various federal agencies is also used as an exogenous policy element in the equation for single-family housing starts (see equation 4 above). In adopting this method, we can be quite confident that deposit flows are measuring phenomena only on the supply side of the mortgage market. In principle, there could be feedbacks on deposit markets from housing markets, with strong housing demand driving up interest rates on mortgages, spilling over to higher deposit rates, and resulting finally in higher deposit flows. It seems, however, that this process operates, if at all, with long lags, and obviously it cannot operate with Regulation Q ceilings determining deposit rates.

To be sure, the use of deposit flows to thrift institutions as the measure of credit availability ignores sources other than those deposit flows that influence the disequilibrium component of the supply of mortgage credit. For example, life insurance companies, pension funds, mortgage companies, and commercial banks have altered their degree of penetration into mortgage markets at various times, sometimes reflecting changes in the differential between interest rates on mortgages and those on other investment assets. It is our view nonetheless that the predominant part of mortgage credit rationing over the cycle arises from disintermediation out of thrift institutions. This is the case both because of the key role of the thrift institutions in the mortgage market and because of the highly cyclical pattern of their deposit flows. The changing penetration and portfolio adjustments of the other institutions have occurred more often in a long-term, trend context, with limited short-term impacts on the rationing of mortgage credit.

The equation for the interest rate on mortgages is specified in a format consistent with this disequilibrium view of the mortgage market. Following the work of Jaffee,[19] changes in the mortgage interest rate are modeled as a partial adjustment process:

$$\Delta RM = k(RM^* - RM_{-1}), \tag{6}$$

where RM is the quoted interest rate on mortgages and RM^* is the equilibrium value. The equation indicates that the interest rate on mortgages moves toward its equilibrium value, but only gradually at a speed depending on the size of the parameter, k.

The equilibrium value of the interest rate on mortgages, RM^*, is specified in a reduced-form framework as a function of the exogenous demand and supply factors affecting the mortgage market:

$$\begin{aligned} RM^* = {} & c_0 + c_1 RTB + c_2 R3\text{–}5 + c_3 RAAA + c_4 RSL \\ & + c_5(\Delta DEP)/(PH \cdot SSF) + c_6(FAC)/(PH \cdot SSF), \end{aligned} \tag{7}$$

where

RTB = interest rate on three-month Treasury bills
$R3\text{–}5$ = interest rate on three- to five-year government bonds
$RAAA$ = interest rate on Aaa corporate bonds (Moody's)
RSL = average effective deposit rate at savings and loan associations
DEP = level of deposits at thrift institutions
PH = quality-adjusted price index for new single-family homes
SSF = single-family housing starts
FAC = sum of new mortgage commitments issued by FNMA, FHLMC, and GNMA and the net change in outstanding FHLBB advances.

19. See Dwight M. Jaffee, "An Econometric Model of the Mortgage Market," in Edward M. Gramlich and Dwight M. Jaffee, eds., *Savings Deposits, Mortgages, and Housing: Studies for the Federal Reserve-MIT-Penn Economic Model* (Lexington, 1972), pp. 139–208.

The three variables, *RTB*, *R3–5*, and *RAAA* are interest rates on securities of short-, medium-, and long-term maturities, respectively. They enter RM^* as indicators of opportunity cost in both the demand and supply sides of the market; they consequently should display strong and positive coefficients.

The *RSL* variable introduces a more novel, and possibly controversial, element. The *RSL* term is calculated as total interest payments made by savings and loan associations on deposits, divided by the total deposits in those associations; it is thus the average effective interest rate on deposits. The variable enters equation 7 as a cost factor that is marked up as thrift institutions change mortgage interest rates in line with changes in their cost of funds. This specification creates a direct link between forces that change *RSL* (such as changes in Regulation Q ceilings) and the interest rate on mortgages.

The last two variables of 7 represent forces that affect the demand-supply balance in the mortgage market. The ratio of net deposit flows for thrift institutions to the value of single-family housing starts should display a negative coefficient because rising deposit flows or declining housing starts would indicate greater relative supply in the mortgage market and thus lower interest rates on mortgages. The final variable reflecting the mortgage commitments of federal agencies should also have a negative coefficient, as increased commitments and advances place downward pressure on the interest rate on mortgages.

The estimated equation for the interest rate on mortgages is derived by substituting 7 into 6, with the following result for the period from 1965:3 to 1978:2:[20]

$$
\begin{aligned}
(8) \qquad \Delta RM = {} & \mathit{constant} + \underset{(4.0)}{0.07RTB} + \underset{(1.8)}{0.08R3\text{–}5} + \underset{(3.0)}{0.22RAAA_{-1}} \\
& + \underset{(4.1)}{0.37RSL_{-1}} - \underset{(-3.7)}{1.4(\Delta DEP)/(PH \cdot SSF)} \\
& - \underset{(-2.6)}{1.3(FAC)/(PH \cdot SSF)} - \underset{(-7.6)}{0.57RM_{-1}},
\end{aligned}
$$

$R^2 = 0.846$; Durbin-Watson $= 1.85$; standard error $= 0.076$; rho $= 0.60$.

The equation fits well with a standard error of less than 8 basis points. All coefficients are statistically significant and correctly signed. The speed

20. The deposit-flow variable enters as a three-quarter distributed lag.

of adjustment, corresponding to k in equation 6, has the reasonable value of 57 percent a quarter. The RSL variable is highly significant, and has a coefficient equal in magnitude to the sum of the coefficients of the interest rates in the capital market. A number of experiments were carried out to "shake" this variable, but it proved stable. Thus a strong element of markup pricing over deposit costs for the interest rate on mortgages appears confirmed.

Because the sum of the coefficients on the four variables representing interest rates is 0.74, a 1 percentage point change in each of these rates would cause the rate on mortgages to rise by 74 basis points within two quarters (noting that two of the variables enter with one-quarter lags). In the long run the interest rate on mortgages would rise by 130 basis points, taking into account the effect of the lagged dependent variable. It is not surprising that this long-run response ratio is greater than unity because, in fact, the mortgage rate is typically higher than a weighted average of the four rates due to risk and maturity factors. The last two variables of 8, which represent measures of the demand-supply balance in the mortgage market, are quite significant statistically, although the magnitude of their effect on the interest rate on mortgages is relatively small. For example, a 10 percent change in deposit flows or agency commitments would have an impact on the order of 2 basis points. Still, large changes in these ratios have occurred and may be maintained, so that the cumulative effect may be appreciable.

DEPOSIT FLOWS

Deposit flows to thrift institutions (savings and loan associations and mutual savings banks) are modeled as the outcome of decisions on portfolio allocation by the household sector. Demand-side influences by the thrift institutions themselves are ignored because of the dominant role of Regulation Q ceilings over the sample period. The approach used here, following the work of Rosen,[21] distinguishes between the flow of deposit funds arising from new saving and the portfolio reallocation of existing

21. See Kenneth Rosen, "The Disintermediation Function: A Gross Flows Model of Savings Flows to Savings and Loan Associations," Research Memo 23 (Princeton University, Financial Research Center, March 1977).

funds that arises from interest rate differentials. A formulation capturing these influences is

$$\begin{aligned}(9) \qquad \Delta DEP = d_0 &+ [d_1 + d_2(RTB - RSL)]SAV \\ &+ [d_3 + d_4(RTB - RSL)]DEP_{-1} \\ &+ d_5 RSL(DEP_{-1}),\end{aligned}$$

where SAV is personal saving.

The first term represents the allocation of personal saving, with the proportion allocated to deposits of thrift institutions depending in part on interest rate differentials; thus d_2 is expected to be negative. The second term represents the allocation of existing funds, with the same structure as the first term, but with DEP_{-1} replacing SAV. The last term is introduced to account for the "interest credited" component of deposit flows to thrift institutions, which is specified as the effective interest rate on deposits times the level of outstanding deposits. The d_5 coefficient represents the proportion of interest credited that is retained on deposit.

Based on the previous work of Rosen, the d_4 coefficient, representing the portfolio reallocation effect, is expected to show the greatest interest-rate elasticity. The d_2 coefficient, representing the allocation of new saving, in contrast, has displayed only a negligible influence. This asymmetry emerges because inflows and outflows of gross saving are themselves frequently asymmetrical. Particularly during periods of disintermediation, gross inflows remain quite stable, with little apparent response to interest rates (as reflected in the d_1 and d_2 coefficients). In contrast, gross outflows indicate strong responses to interest rates (approximated here by the d_3 and d_4 coefficients).

The yield on deposits in 9 is measured by *RSL,* the *average* effective rate for savings and loan associations. In principle, a marginal rate—that is, the deposit rate on the account category relevant at the margin to household decisionmakers—would be preferable, but such a data series is not available. Experiments were carried out with approximations besides *RSL*, namely the Regulation Q ceiling rates (both for passbooks and certificates) and a mixture used in the MIT-Penn-SSRC econometric model. The *RSL* series was adopted because it fitted the data well and in the same way as the alternatives, and also is appropriate both for the d_5 term in 9, and for 8, the equation explaining the interest rate on mortgages.

The results of estimating 9 for the period from 1965:2 to 1978:2 are

$$(10)\quad \Delta DEP = constant + \underset{(5.5)}{0.11SAV} - \underset{(-11.9)}{0.10(RTB - RSL)DEP_{-1}} + \underset{(3.4)}{0.002RSL(DEP_{-1})},$$

$R^2 = 0.962$; Durbin-Watson = 1.92; percentage standard error = 14.64; rho = 0.5.

As expected, the coefficients d_2 and d_3 in 9 were not significantly different from zero, and they have been omitted from the final equation. The equation fits quite well, with a percentage standard error of less than 15 percent; the coefficients are significant with the correct signs. The responsiveness of deposit flows to the interest rate, as measured by the second variable of 10, is large, with a change of 1 percentage point in the Treasury bill rate (*RSL* remaining fixed) causing a change of 10 percentage points in the growth rate of deposits. The coefficient of the interest-credited variable, the last term in 10, implies that about 80 percent of interest credited is retained on deposit.[22]

Linking the Deposit, Mortgage, and Housing Markets

The estimated equations for deposit flows, ΔDEP, the interest rate on mortgages, *RM*, and housing starts, *HS*, highlight the various links among the sectors of the model. These variables are influenced by interest rates on securities in the capital markets, *RCAP*, the average effective interest rate on the deposits of thrift institutions, *RLS*, and by one another (as well as a number of exogenous variables). These linkages can be seen in the following summary:

Dependent variable	Independent variable			
	RCAP	*RSL*	ΔDEP	*RM*
ΔDEP	−	+	...	...
RM	+	+	−	...
HS	...	...	+	−

22. To see this, note that *RSL* is measured as an annual rate and in percentage points. If it were translated to a quarterly rate and measured as a fraction, the coefficient shown as 0.002 would have been 0.80.

Figure 2. Links among Housing, Mortgage, and Deposit Markets

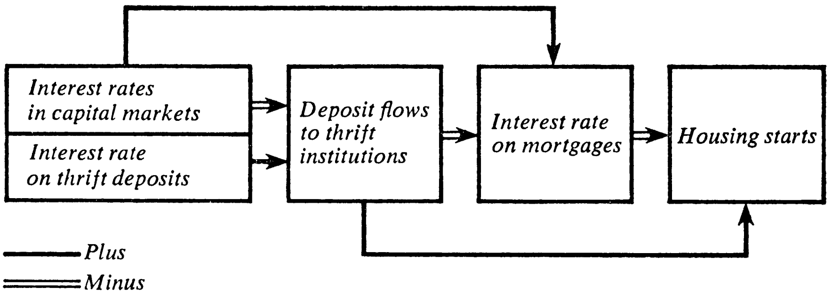


Figure 2 uses a flow diagram to characterize the same three-equation system. Three main points deserve emphasis.

First, interest rates on securities, *RCAP,* affect housing starts negatively through two channels. In one channel, higher values of *RCAP* directly increase interest rates on mortgages; in the other, they reduce deposit flows, which then raise interest rates on mortgages. These two channels account for the strong impact of conditions in security markets on housing activity that is confirmed in most studies.

Second, deposit flows to thrift institutions, ΔDEP, affect housing starts through two channels, both with positive effects: by directly enhancing credit availability; and by operating to reduce interest rates on mortgages.

Third, interest rates on thrift deposits, *RSL,* affect housing starts through two channels, *but with offsetting signs:* in one channel, higher values of *RSL* increase deposit flows and hence stimulate housing starts; in the other channel, higher values of *RSL* increase interest rates on mortgages (through the cost markup process), and the higher mortgage interest rates then depress housing activity. Thus factors that change *RSL,* such as changes in Regulation Q ceilings (including MMCs), have a theoretically ambiguous effect on activity in the housing market. The effect of *RSL* on interest rates for mortgages is also ambiguous because higher values of *RSL* tend to raise *RM* through the cost markup channel and to lower *RM* because of larger deposit flows. The simulation results reported below provide measures of the relative importance of these various channels and of the net effect of MMCs on interest rates for mortgages and on housing starts.

Simulations of the Individual Equations

The five structural equations of the model were estimated with sample periods ending in 1978:2, while in fact data are now available through 1979:2. This procedure provides an opportunity for checking the fit of the individual equations beyond the sample period and then, in the next section, for checking the performance of the full model. Single-equation dynamic simulations are used in this section; each equation is simulated by itself, taking other data as exogenous, but with dynamic feedback through any lagged dependent variables.

The results, presented in table 6, show the actual, simulated, and residual (actual minus simulated) values for the five equations. In evaluating these results, we looked for simulation errors that were especially large (relative to the standard error of the estimated equation) or that consistently had the same sign. With the obvious exception of the equation for deposit flows, the estimated relationships hold quite well. An overestimate of single-family housing starts by about 300,000 units (annual rate) in 1979:1 does stand out. But the extremely cold and snowy winter at that time was generally perceived by housing experts to have reduced actual single-family starts by about that amount.[23]

In contrast, deposit flows to thrift institutions are significantly too low in the simulation, with an accumulated underestimate of about $32 billion over the four-quarter period. Because MMCs were first issued in June 1978 and had a major effect during the subsequent year, and because the estimated equation has no special features accounting for the certificates, it seems plausible that the residuals in the simulation are related to the MMCs. Indeed, on a closer analysis, which we shall now describe, the pattern of residuals is remarkably close to direct measures of the impact of the MMCs. *Actual* deposit flows to thrift institutions during the period (as shown in table 6) obviously include the net impact of the certificates. We wish to make certain adjustments to the simulated series so that it can be interpreted as an estimate of deposit flows to thrift institutions in the

23. One might have expected these units to be made up in the spring quarter. However, the nature of the sequential production process in housing and the capacity constraint on the industry in the spring limit the feasibility of such a seasonal catch-up. See Kenneth T. Rosen, *Seasonal Cycles in the Housing Market: Patterns, Costs, and Policies* (MIT Press, 1979).

Table 6. Single-Equation Simulations of Housing and Mortgage Variables, and Actual Values, 1978:3–1979:2

Item	*1978:3*	*1978:4*	*1979:1*	*1979:2*
Change in number of owner-occupied units (thousands)				
Actual	323	317	333	346
Simulated	350	345	333	324
Residual	−27	−28	0	22
Single-family housing starts (thousands, at an annual rate)				
Actual	1,426	1,471	1,204	1,247
Simulated	1,430	1,494	1,507	1,280
Residual	−4	−23	−303	−33
Multifamily housing starts (thousands, at an annual rate)				
Actual	606	579	494	557
Simulated	648	583	544	478
Residual	−42	−4	−50	79
Interest rate on mortgages (percentage points)				
Actual	9.71	9.95	10.23	10.52
Simulated	9.70	10.02	10.29	10.60
Residual	0.01	−0.07	−0.06	−0.08
Deposit flows to thrift institutions (billions of dollars)				
Actual	16.3	14.8	13.3	8.8
Simulated	10.4	3.4	2.6	4.4
Residual	5.9	11.4	10.7	4.4

Sources: Simulated—derived from text equations 2, 4, 5, 8, and 10, taking other data in each equation as exogenous, but allowing for dynamic feedback through any lagged dependent variables; actual—see appendix. The housing starts series are seasonally adjusted.

absence of the MMCs. The resulting *residuals* from the adjusted simulation then provide an estimate of the net impact of the certificates and can be compared to available direct measures of their impact. We also develop a second approach in which the simulated series is adjusted so that it *includes* the impact of the MMCs; if that adjustment is successful, the resulting simulation should closely track the actual series.

In the equation for deposit flows to thrift institutions (10), *RSL includes* the impact of the certificates on the *average* interest rate on (total) deposits of those institutions but by the same token *excludes* most of the impact on the *marginal* yield made available to depositors by these certificates. For example, at the point when MMCs were introduced, they had no effect on the average rate, but they provided a much higher yield on the margin to potential savers. Thus the *interest differential term* in the equation, $(RTB - RSL)$, clearly would underestimate the impact of MMCs by including their effect on the average, rather than the marginal, interest rate. On the other hand, no problem arises in the *interest-credited term* of the equation because the average deposit rate is the relevant concept for that effect.

SIMULATION EXCLUDING MONEY-MARKET CERTIFICATES

For the first approach, we want to purge both the interest-differential and the interest-credited terms of any impact of the MMCs; for the second approach, we wish to do the opposite, that is, to include the impact of the MMCs correctly in both terms. Implementing the first approach, we calculate an adjusted series for *RSL,* called *RSLX,* that is intended to remove the influence of the MMCs on the average deposit rate for the period 1978:3 to 1979:2. We then substitute *RSLX* for *RSL* in both terms of equation 10 and calculate simulated values that estimate what deposit flows of thrift institutions would have been in the absence of MMCs. The values for *RSLX* are determined by estimating an equation for *RSL* for the period from 1966:1 to 1978:2, and then simulating the values through 1979:2. Because the period ending in 1978:2 does not include the effects of MMCs, the simulated values should also be free of any influences from these certificates.

For this purpose, the following equation links *RSL* to the Treasury bill rate, *RTB;* to Regulation Q ceiling rates on passbook deposits, *RPB,* and on previously authorized certificates, *RCT;* and to its own lagged value for the period from 1966:1 to 1978:2, as follows:

$$(11)\quad RSL = \mathit{constant} + \underset{(3.0)}{0.07RCT} + \underset{(2.8)}{0.01}(RTB - RPB) + \underset{(27.7)}{0.90RSL_{-1}},$$

$R^2 = 0.999$; Durbin-Watson $= 2.03$; standard error $= 0.02$; rho $= 0.40$.

The interest rates on Treasury bills and on passbook deposits are entered as a differential to indicate that changes in these two interest rates influence the average effective rate by changing the incentive of depositors to

Table 7. Effective Interest Rate and Deposit Flows to Thrift Institutions, Actual and Simulated in the Absence of Money-Market Certificates, 1978:3–1979:2

Item	*1978:3*	*1978:4*	*1979:1*	*1979:2*
Effective interest rate on deposits to thrift institutions (percentage points)				
Actual	6.65	6.75	7.05	7.25
Simulated	6.61	6.66	6.71	6.75
Residual	0.04	0.09	0.34	0.50
Deposit flows to thrift institutions (billions of dollars)				
Actual	16.3	14.8	13.3	8.8
Simulated	10.2	2.9	0.7	1.6
Residual	6.1	11.9	12.6	7.2
Addendum: Actual net change in money-market certificates	25.4[a]	30.2	38.9	15.4

Sources: Simulated—derived from text equations 10 and 11 as described in the text; actual—see appendix. Data on money-market certificates are from the Board of Governors of the Federal Reserve System.
a. This figure includes data for June 1978.

shift the mix of funds toward certificate accounts. The lagged dependent variable indicates a speed of adjustment of 10 percent a quarter in these processes. The equation fits the data well; its simulated values for 1978:3 to 1979:2 are shown in table 7. As expected, these simulated values lie below the actual effective deposit rate because the equation makes no allowances for MMCs. Indeed, it is for this reason that the simulated values can be inserted as *RSLX* into equation 10 to generate estimates of deposit flows to thrift institutions in the absence of MMCs; those results also appear in table 7. In the table we interpret the *simulated* deposit flows as a hypothetical estimate of how deposits would have behaved in the absence of MMCs. Because the deposit flows obviously reflect the full impact of MMCs, the *residuals* represent an estimate of the net impact of MMCs. The accumulated sum of residuals is about $38 billion for the four-quarter period, and this sum can now be compared with the available data on actual MMC flows.

The actual data indicate that the volume of MMCs at thrift institutions rose to a net amount of $109.9 billion by the middle of 1979. Clearly, the net effect of MMCs on the total deposits of thrift institutions was substantially smaller than the $110 billion figure to the extent that MMCs absorbed funds from other accounts at thrift institutions. It is estimated, in the absence of available data, that more than half of the net change in MMCs for savings and loan associations and nearly all the net change at mutual savings banks were simply transfers from other accounts at thrift institutions. Thus a comparison of the \$38 billion estimate in table 7 with the actual net flow of \$110 billion implies that, in the aggregate, about two-thirds of funds flowing into MMCs at thrift institutions were attracted from other thrift accounts. This appears fully consistent with the available estimate.

Moreover, the time pattern of the residual estimates of table 7 is consistent with actual experience. Beginning with the introduction of MMCs in June 1978, their growth accelerated through 1978 as interest rates rose and as more institutions offered the certificates; growth then leveled off during 1979:1, as did short-term interest rates. Finally, growth declined in 1979:2, in part reflecting additional regulations that were imposed on the MMCs in March 1979, which reduced their attractiveness to some extent.[24] The data for deposit flows to thrift institutions in table 7 show this pattern clearly. The simulated series, which we interpret as the way deposit flows would have performed in the absence of MMCs, declined sharply during 1978:4 and 1979:1 under the pressure of high short-term rates and then recovered slightly in 1979:2 as these conditions temporarily eased. The residual series, which we interpret as the net contribution of MMCs, rose during 1978:3 and 1978:4, leveled off in 1979:1, and then declined quite sharply in 1979:2.

SIMULATIONS INCORPORATING MMCS

The second approach for evaluating the implications of MMCs adjusts the *RSL* series as it enters equation 10 to include the effects of the certificates on marginal (as well as average) deposit rates. As noted above, the historical values of *RSL* are correct for this purpose in the interest-credited term of 10, but not in the *interest differential* term. Indeed, the key feature of the MMCs was that they provided depositors with marginal yields several percentage points higher than the average contained in *RSL*. The obvious series to use for this marginal yield from 1978:3 to 1979:1 is the six-month Treasury bill rate itself because it was the basis

24. Specifically, the new regulations eliminated the compounding of returns within the six-month maturity and the differential of 0.25 percent in favor of the thrift institutions when the six-month Treasury bill rate exceeds 9 percent.

Table 8. Deposit Flows to Thrift Institutions, Actual and Simulated Incorporating Money-Market Certificates, 1978:3–1979:2
Billions of dollars

Item	*1978:3*	*1978:4*	*1979:1*	*1979:2*
Actual	16.3	14.8	13.3	8.8
Simulated	13.9	13.6	13.9	10.9
Residual	2.4	1.2	−0.6	−2.1

Sources: Simulated—derived from text equation 10 as described in table 6, with the effective interest rate on deposit flows of thrift institutions replaced by the six-month Treasury bill rate for 1978:3–1979:1 and by that rate minus 75 basis points for 1979:2 in the equation's interest differential term; actual—see appendix.

for calculating the ceiling rate on MMCs during this period.[25] During 1979:2, on the other hand, inflows reflected the regulatory changes made in March that lowered the ceiling rate effectively below the six-month Treasury bill rate. A reasonable estimate is that the restrictions lowered the ceiling by about 75 basis points relative to the six-month Treasury bill rate. Setting *RTB6X* equal to the six-month Treasury bill rate from 1978:3 to 1979:1 and below that rate by 75 basis points in 1979:2, we carried out an additional extrapolation with *RTB6X* replacing *RSL* in the interest-differential term of the deposit-flow equation. The results of that extrapolation are shown in table 8. The fit is now quite good, and it is evident that replacing *RSL* with *RTB6X* in the deposit-flow equation eliminates the systematic underestimate of the deposit flow shown in table 6.

Simulation Results for the Full Model

The econometric model of the housing, mortgage, and deposit markets described here combines the five estimated equations with three equations for housing and rent prices and four accounting identities that determine the outstanding stock and the vacancy rate for the two types of structures.[26] The model is dynamically simulated, first to quantify the impact

25. We feel confident in ignoring the minor but complex adjustments to the rate on six-month Treasury bills that would be required to measure exactly the yield paid by the thrift institutions on the MMCs.

26. The three pricing equations cover single-family house prices, *PH;* the rental component of the consumer price index, *CPIR;* and the home ownership component of the consumer price index, *CPIO*. These equations are of limited interest by themselves, and primarily serve to close the model. They are available from the authors on request.

of the MMCs on activity in the housing and mortgage markets, and then to identify the channels through which such effects operate. The simulations are carried out for four quarters beyond the end of the estimation period, 1978:3 to 1979:2—which, except for the June 1978 observation, coincides with the available data for the MMC period.

SIMULATION WITH MONEY-MARKET CERTIFICATES

The first experiment is essentially a historical simulation of the housing and mortgage sectors during the 1978:3 to 1979:2 period, and includes the impact of the MMCs. A key property of the simulation relates to the treatment of the deposit flows to thrift institutions. Because the equation for deposit flows has only exogenous variables among its independent variables, there is no loss in making these flows themselves exogenous for the purposes of this simulation, and we follow this course. This guarantees, of course, that the impact of the MMCs on deposit flows is fully incorporated in the results. Alternatively, the equation for deposit flows, with the adjusted six-month Treasury bill rate, *RTB6X*, serving as the marginal deposit rate, tracks the actual flows closely, and thus provides similar results.

Table 9 shows the actual, simulated, and residual values of this simulation. In view of the close fits reported for the single-equation simulations discussed above, it is not surprising that the model tracks well even allowing for dynamic interaction of the equations. The largest error in the simulation—for housing starts in 1979:1—has been explained above.

SIMULATION WITHOUT MONEY-MARKET CERTIFICATES

A second simulation was carried out to provide quantitative estimates of how the deposit, mortgage, and housing sectors would have performed in the absence of MMCs. The principal change from the previous simulation is that the deposit flows to thrift institutions are now treated as an endogenous element of the model. Moreover, the average effective interest rate paid on these deposits, *RSL,* is replaced with *RSLX,* following the discussion and results of table 7 above. The simulated values of the deposit-flow equation then correspond to an environment without MMCs.

The results of the simulation without MMCs are shown in table 10 as deviations from the previous simulation with MMCs. The values shown

Table 9. Multiequation Simulation of Housing and Mortgage Variables, and Actual Values, 1978:3–1979:2

Item	*1978:3*	*1978:4*	*1979:1*	*1979:2*
Change in the number of owner-occupied units (thousands)				
Actual	323	317	333	346
Simulated	350	344	339	329
Residual	−27	−27	−6	17
Single-family housing starts (thousands, at an annual rate)				
Actual	1,426	1,471	1,204	1,247
Simulated	1,440	1,504	1,519	1,281
Residual	−14	−33	−315	−34
Multifamily housing starts (thousands, at an annual rate)				
Actual	606	579	494	557
Simulated	638	582	543	493
Residual	−32	−3	−49	64
Interest rate on mortgages (percentage points)				
Actual	9.71	9.95	10.23	10.52
Simulated	9.70	10.01	10.29	10.63
Residual	0.01	−0.06	−0.06	−0.11
Deposit flows to thrift institutions (billions of dollars)[a]				
Actual	16.3	14.8	13.3	8.8

Sources: Simulated—derived from text equations 2, 4, 5, and 8 and from three equations for housing and rent prices and four accounting identities not presented in the text, as described in table 6; actual—see appendix. The housing starts series are seasonally adjusted.

a. This variable is treated as exogenous in the simulation, thus guaranteeing that the impact of money-market certificates is fully incorporated in the results.

can thus be interpreted as the effects of introducing MMCs during the period, as estimated by the model. The results indicate a strong, positive impact of the MMCs on housing activity.

Specifically, deposit flows show an accumulated net addition of $37.8 billion over the four-quarter period resulting from the introduction of the MMCs. These results in table 10 for deposit flows are identical to the results previously shown as the residuals for the deposit-flow equation in table 7. This occurs because the determinants of deposit flows in the model are all exogenous variables.

Table 10. Net Effect of Money-Market Certificates on Housing and Mortgage Variables, 1978:3–1979:2

Item	*1978:3*	*1978:4*	*1979:1*	*1979:2*	*Total*
Change in the number of owner-occupied units (thousands)	0	16	23	12	52
Single-family housing starts (thousands, at an annual rate)	27	111	233	147	122
Multifamily housing starts (thousands, at an annual rate)	59	178	301	171	169
Interest rate on mortgages (percentage points)	0.00	−0.02	−0.09	−0.08	−0.08
Deposit flows to thrift institutions (billions of dollars)	6.1	11.9	12.6	7.2	37.8

Source: Calculated as the difference between the results of the simulation incorporating money-market certificates presented in table 9 and a simulation excluding them, as described in the text. Figures are rounded.

Interest rates on mortgages show little net effect from the introduction of the MMCs. The change by 1979:2 is a decrement of 8 basis points, with the maximum effect during the period a decrement of 9 basis points in 1979:1. As discussed above, the net effect on the interest rate of mortgages is the result of two offsetting forces: downward pressure created by augmented deposit flows and upward pressure created by increased costs of funds for thrift institutions. In fact, each of these effects taken alone has an impact of about 25 basis points during the 1978:3 to 1979:2 period, with the deposit flow dominating by a modest margin.

Housing starts are distinctly and positively affected by the MMCs. For the four-quarter period, total starts are 291,000 units higher in the presence of the MMCs, with about 40 percent of the effect on single-family units and about 60 percent on multifamily units. The primary channel for this effect is the augmented deposit flow, although the small decrement in the mortgage rate reinforces it slightly. The larger effect of MMCs on multifamily units is reasonable in view of the historical relationship that indicates a greater cyclical sensitivity of multifamily than of single-family starts. Thus, to the extent that the MMCs have offset one factor creating this cyclical sensitivity, the greater support for multifamily housing starts is not surprising.

These simulation results also provide a measure of the proportion of cyclical declines in housing starts that can be attributed to reduced availability of credit. They imply that, in the absence of MMCs, housing starts in 1979:2 would have occurred at an annual rate just under 1.5 million units, a decline of about 500,000 from the 2.0 million pace of 1978. Thus our estimate of an increment of about 300,000 units, both for the four quarters combined and for the annual rate of 1979:2, indicates that more than half of the potential decline was avoided through the introduction of the MMCs in June 1978.

In line with the housing starts, our results indicate that the number of owner-occupied units was higher by about 52,000 during the 1978:3 to 1979:2 period because of the presence of MMCs. That is less than the 122,000 increment in single-family housing starts, indicating that decisions on tenure choice are less sensitive to credit availability than decisions on housing starts. An interesting implication is that the MMCs slowed the actual decline in vacancy rates by augmenting the stock of available units more than the stock demand for these units.

SIMULATION OF THE IMPACT OF FEDERAL AGENCIES

In a final simulation, we explore the impact during 1978–79 of the federal agencies that supply credit to the mortgage market. In this model, the activity of these agencies was summarized in the variable *FAC*, which includes the new mortgage commitments of GNMA, FNMA, and FHLMC, and the net change in advance loans of the FHLBB. The variable *FAC* enters the model in the equations explaining the mortgage rate and single-family housing starts. Higher values for *FAC* reduce the interest rate on mortgages and stimulate single-family housing starts.

The activity of these agencies in the 1978–79 period was somewhat unusual. The quarterly values of *FAC* from 1977:1 to 1979:2 are as follows.

	First quarter	*Second quarter*	*Third quarter*	*Fourth quarter*
1977	2.9	6.3	5.6	7.7
1978	8.2	13.2	9.7	9.3
1979	2.3	8.1	...	...

The year 1977 could be characterized as a relatively standard year for the agencies, with the flows below previous peaks in nominal terms, and distinctly below them when measured relative to housing prices. The low value in 1977:1 also reflects a characteristic, seasonal pattern. The year 1978, in contrast, shows record high values in nominal terms in every quarter, and in real terms in the first and fourth quarters. The data for 1979:1 and 1979:2 then show a return to more typical levels. The activities of the federal agencies during 1978 have been criticized for stimulating an already strong housing market, especially in a period of accelerating inflation.

With this background, we carried out a simulation in which the values for *FAC* during 1978 were replaced with the corresponding quarterly values that occurred during the more typical year of 1977. The simulation was carried out with MMCs in the model (see table 9) and the results, shown as deviations from the base with MMCs in the model are as follows.[27]

	1978:3	*1978:4*	*1979:1*	*1979:2*	*Total*
Interest rate on mortgages (percentage points)	−0.03	−0.05	−0.06	−0.04	...
Single-family housing starts (thousands, at an annual rate)	39	38	22	6	23

The values indicate relatively modest effects from the high, actual federal agency activity. Interest rates on mortgages are lower, as expected, when the activity of the agencies is included in the market, but the maximum impact was only 6 basis points in 1979:1. Single-family housing starts are higher, because of the increase in agency activity and the decline in interest rates on mortgages, with a four-quarter cumulative increase of 23,000 units. The impact on housing starts was centered in the last two quarters of 1978, with a simulated increase close to 40,000 units at annual rates in both quarters. Thus, while the results confirm that federal agency policy stimulated housing activity during 1978–79 (perhaps unfortunately), the number of housing units is not large, especially when compared with the impact of the MMCs.

27. These results are generated by replacing values for *FAC* during 1978 with actual 1977 values, and are derived from the simulation results of table 9 minus the simulation results with the (lower) 1977 actual values of *FAC*. The data for housing starts are seasonally adjusted at annual rates.

Conclusions

The paper has developed, estimated, and simulated a five-equation model of the deposit, mortgage, and housing sectors of the U.S. economy. The theoretical structure emphasized the following points:

Stock-level, housing-demand schedules incorporate demographic, relative price, and mortgage availability factors.

Flow-level, housing-supply schedules determine multifamily housing starts as a function of profit incentives for the construction industry.

Flow-level, housing-demand schedules determine single-family housing starts as a stock adjustment response to stock-level housing demand.

Deposit flows to thrift institutions allow for new saving allocations and existing deposit reallocation as a function of available funds and interest rate differentials.

Interest rates on mortgages are determined by a process of disequilibrium adjustment with exogenous demand and supply factors.

Estimation and single-equation simulation results were consistent with the theory and provided close fits in all cases. The one serious indication of simulation error was evident in the equation for deposit flows to thrift institutions, where the existence of MMCs had to be taken into account to fit the actual data. In fact, however, when the six-month Treasury bill rate was used as the marginal interest rate for household depositors, the fit became remarkably close.

The simulation experiments focused on the reasons for the unexpected strength in housing construction during the last half of 1978 and the first half of 1979. The results indicate that the introduction of the MMCs in June 1978 is the principal factor responsible for the strong showing by housing. The MMCs at thrift institutions grew by about $110 billion by the middle of 1979; about one-third ($38 billion) of that total is estimated to represent net "new money." Simulation experiments indicated that housing starts during the interval from 1978:3 to 1979:2 would have been almost 300,000 units lower in the absence of the MMCs. The simulation results showed also that the MMCs augmented housing starts mainly by increasing the availability of mortgage credit, with only a small effect from lower interest rates on mortgages.

The activity of federal credit agencies in the mortgage market was also high during 1978, but the simulation results indicate a more modest effect on housing starts, about 23,000 units from this source between 1978:3 and 1979:2. The demand for housing as an investment asset also appears to have contributed little to the number of housing starts during the 1978–79 period. Our data indicate that the widely publicized "surge toward home ownership" is exaggerated, and the part that does exist affects the demand for existing homes (and existing home prices) much more than the number of new housing starts.

Considering the near-term prospects for housing activity, we find that cyclical fluctuations in home building continue to be determined largely by the pattern of deposit flows to thrift institutions. For example, those deposit flows may decline sharply under the pressure of high short-term interest rates on securities if MMCs fail to augment inflows strongly because of regulatory limitations placed on the certificates or because thrift institutions do not offer the allowed ceiling rate. In that event, a more traditional, sharper cyclical decline in housing starts may develop during late 1979 and early 1980.

APPENDIX

Variables and Data Sources

THE FOLLOWING variables appear in the text.

CPIO = home ownership component of the consumer price index (1967 = 100), quarterly averages of data (not seasonally adjusted) from the Bureau of Labor Statistics.

CPIR = rent component of the consumer price index (1967 = 100), quarterly averages of data (not seasonally adjusted) from the Bureau of Labor Statistics.

CPIT = consumer price index, all items for all urban consumers (1967 = 100), quarterly averages of data (not seasonally adjusted) from the Bureau of Labor Statistics.

DEP = outstanding deposits of savings and loan associations and mutual savings banks (billions of dollars), end-of-quarter data (not seasonally adjusted) from the Board of Governors of the Federal Reserve System.

FAC = sum of new mortgage commitments issued by the Government National Mortgage Association, Federal National Mortgage Association, and Federal Home Loan Mortgage Corporation, and the net change in Federal Home Loan Bank advances (billions of dollars), quarterly rates (not seasonally adjusted), from *Federal Reserve Bulletin,* various issues, and from the Government National Mortgage Association.

HADJ = number of owner-occupied housing units, adjusted for 1970 owner-occupancy rates (thousands). See the text for construction technique.

HOWN = number of owner-occupied housing units (thousands), calculated as the product of the owner-occupancy rate and the number of households, from Bureau of the Census, *Housing Vacancy Survey,* various issues; and *Current Population Survey,* P-20, *Population Characteristics,* and P-25, *Population Estimates and Projections,* various issues.

KSF and *KMF* = outstanding stock of single- and multifamily housing units, respectively (thousands), constructed using perpetual inventory technique with constant depreciation rates fitted for data from Bureau of the Census, *Census of Population, 1970* and *Annual Housing Survey,* 1974–76.

PH = index of housing prices for new homes, adjusted for 1974 house characteristics (hundred thousand dollars, not seasonally adjusted), from Bureau of the Census, *Construction Reports,* C27, *Price Index of New One-Family Houses Sold,* various issues.

SAV = personal saving (billions of dollars, seasonally adjusted at annual rates), from Bureau of Economic Analysis, national income and product accounts.

SSF and *SMF* = single- and multifamily housing starts, respectively (thousands), quarterly data (not seasonally adjusted), from the Bureau of the Census.

RAAA = Moody's Aaa corporate bond rate (percent), quarterly averages from *Federal Reserve Bulletin*, various issues.

RM = mortgage interest rate, savings and loan associations (percent), quarterly averages from *Federal Home Loan Bank Board Journal*, various issues.

RSL = effective deposit rate of savings and loan associations (percent), interpolated from semiannual data from *Federal Home Loan Bank Board Journal*, various issues.

RTB = three-month Treasury bill rate for new issues, bank discount basis (percent), quarterly averages from *Federal Reserve Bulletin*, various issues.

RTB6 = six-month Treasury bill rate for new issues, bank discount basis (percent), quarterly averages from *Federal Reserve Bulletin*, various issues.

R3–5 = rate on three- to five-year government bonds (percent), quarterly averages from *Federal Reserve Bulletin*, various issues.

UR = unemployment rate, all civilian workers (percent), quarterly averages from the Bureau of Labor Statistics.

VO and *VR* = vacancy rate, units for sale, and vacancy rate, rental units, respectively (percent) from Bureau of the Census, *Housing Vacancy Survey*, various issues.

Comments and Discussion

Benjamin M. Friedman: Dwight Jaffee and Kenneth Rosen have written a useful and stimulating paper that highlights in particular the importance of the new money-market certificates among recent developments in the financing of residential construction in the United States. Their paper also addresses a number of other questions, about how the economy works and about what policy should be, which it resolves less clearly. My comments will focus primarily on some of those open questions.

The paper by Jaffee and Rosen treats a subject that is important for at least two reasons. One is that interesting questions persist in the economics of housing supply and demand per se. Among the more significant issues here is that of the relative importance, in the determination of housing demand, of demographic or sociological factors versus variables more familiar to economists. Moreover, even within the category of standard economic variables, there is the issue of those that represent service prices versus those that reflect asset yields. One part of my comments will focus on the authors' emphasis on service-price variables over asset-yield variables.

A second reason why the subject of this paper is important stems from the role that residential construction plays in determining overall U.S. macroeconomic activity. A quick calculation based on the authors' results will readily highlight how significant housing can be in this context. Jaffee and Rosen conclude that, over the one-year period ending last June, the introduction of money-market certificates made a difference of approximately 300,000 housing starts. If the average house price is $60,000 and the consumption multiplier is 2.0, this one new development alone added more than 1.5 percent to the U.S. GNP during that one-year period (before allowance for whatever "crowding out" effects would have occurred within the year). The absence of that 1.5 percent from the GNP between mid-year 1978 and mid-year 1979 would have made a major difference for a number of issues currently receiving widespread attention—for example, whether or not the economy is now, or recently has been, in a recession. In a more general context, Jaffee and Rosen provide evidence showing that, because of the introduction of money-market certificates, the way in which monetary policy affects nonfinancial economic activity in the United States is likely to be different in the future. To the extent that monetary policy has been an important factor in determining the U.S. economy's cyclical behavior, therefore, the pattern of U.S. business cycles is likely to change as well.

After reviewing the various issues that motivate their paper, the authors develop a model of housing, mortgages, interest rates on mortgages, and deposits, and then apply this model to simulate the effects of two kinds of policies: the introduction of money-market certificates, and the support of the mortgage market by federally sponsored credit agencies and mortgage pools. My substantive comments on the paper focus primarily on the construction of the model. In addition, I offer a few comments on the second set of policy simulations.

Three aspects of the model are of interest. The first is the determination of the interest rate on mortgages. Jaffee and Rosen have highlighted what they properly consider to be a novel feature of the model—in particular, the "markup" element according to which the interest rate that thrift institutions pay on their deposits has a positive carry-over effect on the interest rate that they charge on their mortgage loans. Although some economists would object to this proposition as a description of either short-run or long-run behavior by thrift institutions, on the ground that higher deposit rates increase the supply of funds available for mortgage lending, I would not necessarily reject it in the short-run context in which profit pressures could well affect some aspect of the adjustment process of the institutions. The problem, however, is that the equation developed by Jaffee and Rosen does not distinguish between the short run and the long run. In their equation, the rate of interest paid by thrift institutions on their own deposits carries over in a markup fashion to interest rates on mortgages even in the long run. This latter proposition is much more difficult to accept.

It is probably useful to distinguish, therefore, between short-run and long-run aspects of the way in which this markup variable enters the equation for the mortgage interest rate. One way to do so would be to reformulate the model by putting the markup component into an explicit adjustment variable, so that the speed of adjustment of the mortgage rate depends in part on the currently prevailing relationship between the mortgage rate and the deposit rate. The specification here must be somewhat complicated in order to have the adjustment speed vary always in the right way—depending positively on the deposit rate when the mortgage rate is adjusting upward, but negatively if the mortgage rate is adjusting downward. A simple specification, in which the adjustment speed depends positively on the deposit rate regardless of the direction of adjustment, will not be adequate. The best approach under the circumstances is probably a formulation analogous to that which Arthur Treadway suggested for fixed investment.

A second component of the model that warrants close scrutiny is the determination of the quantity of thrift deposits. Here the problem is that the model never directly faces the question of what the plausible substitutes are for thrift deposits in people's portfolios. Although the description in the paper represents the demand for thrift deposits as a function of some generalized vector of yields on other assets, it turns out that the only such yield that in fact enters the relevant equation is the Treasury bill rate. It is probably reasonable to think of that rate as a proxy for the competing yields not only on Treasury bills but also on commercial paper, some Treasury securities with longer maturities, shares of money-market funds, and other short-term open market paper that is, or could be, held by the households who hold the majority of the thrift deposits. Even so, this list does not adequately represent the range of plausible substitutes for deposits at thrift institutions.

As of the end of 1978, households held thrift deposits worth \$625 billion. By contrast, households' total ownership of all assets for which the Treasury bill rate (even broadly interpreted, as above) might serve as a yield proxy was only \$170 billion. What, then, were the other principal financial assets of households? Their other holdings at the end of 1978 included money (M_1), \$222 billion; savings deposits in commercial banks, \$472 billion; and stocks and bonds, \$1,055 billion. Hence by including the Treasury bill rate as the only competing asset yield in the equation, Jaffee and Rosen implicitly assume that this large amount of thrift institution deposits is a substitute for only a narrow slice of the household sector's other asset holdings. Even with a Duesenberry-type formulation, in which thrift deposits are assumed to be substitutable only within the limited class of liquid assets, one would expect that they would at least be substitutes for bank deposits. Indeed, Peter Fortune found that to be true empirically; and Richard Kopcke, using a more general formulation, also found evidence for substitutability between thrift deposits and savings deposits at commercial banks.

In addition to the issue of what competing asset yields to include, the authors' deposit-demand equation raises further questions like whether the equation should include wealth effects, income effects, or lagged stocks of other assets. Most economists would be quite startled, for example, if there were not an income variable in a money (M_1) demand function. If the familiar transactions motive leads people to demand more money as their incomes rise, however, it also has to lead them to demand less of at least some other asset. What should that other asset be? Noncheckable thrift deposits are a plausible candidate, and hence the demand for thrift deposits could well include a (negative) income effect. More generally, there is ample room on the agenda for future research to focus more sharply on the demand for thrift deposits.

The third part of the model on which I will comment is the determination of housing demand. It is at this point that Jaffee and Rosen's treatment of economic variables focuses almost exclusively on those that represent the price of housing services as opposed to those that represent the return on housing as an asset. Rosen's previous work, as well as recent work by Patric Hendershott, has shown that the asset return to home ownership has varied substantially during the past few years. (This variation has come largely from inflation, and it has been importantly affected by the advantages of unrealized capital gains and the tax deductibility of mortgage interest and other house-related expenses.) This asset-yield element of the determination of the demand for housing is not nearly so well captured in the Jaffee-Rosen model as is the service-price element in the sense of the price of housing services relative to the general price level, or the price of owner-occupied housing relative to rental housing.

Finally, I turn to the simulations. Here my concern is not with the simulations of the effects of money-market certificates, which seem quite plausible to me, but instead with the simulations of the effect of federal support for the mortgage market. The authors' main finding on this subject is that, in contrast to money-market certificates, federal support for the mortgage market has been of little importance in accounting for the unexpected recent strength of home-building activity in the United States. This conclusion is somewhat surprising because the year 1978 was a record high for this kind of federal support. The sponsored credit agencies and mortgage pools together provided a record $43 billion in mortgage credit in 1978, more than a quarter of the $149 billion of mortgage credit extended overall. In the single-family home-mortgage market, agencies and mortgage pools provided a record $37 billion, more than one-third of the $106 billion market total. This rapid pace continued into the first half of 1979.

Part of the problem stems from the authors' use of the year 1977 as the base for comparison. Federal support for the mortgage market in that year, which Jaffee and Rosen treat as normal, in fact came to a then-record $28 billion, mainly because of the surge in activity in mortgage pools. Moreover, the state of the economy in 1977 and 1978, in terms of both overall cyclical posture and the level of interest rates in the open market, was hardly comparable to that in 1974, the previous record year. The main problem, however, is that the Jaffee-Rosen model focuses on the sponsored agencies and largely ignores the mortgage pools, which over time have been accounting for a greater share of the total federal support ($18 billion of the $43 billion total in 1978). On balance, therefore, the role of federal support in generating the record volume of U.S. mortgage credit extensions in 1978 remains, at the least, an open question. Whether that amount of support, together with the resulting volume of mortgage credit, was a positive or a negative development remains a useful topic for further discussion and research, despite the implication of the paper that it did not matter much.

Lawrence R. Klein: This is an interesting paper with important estimates, and it is skillfully done. The authors have singled out the unusual factors in this cyclical episode and make plausible estimates. I like their approach, but I think that the last word has not been said on this subject until more refined calculations have been made—calculations that are in the spirit of their investigation, but that go more deeply into some matters.

This has not been a "usual" cyclical downturn. One should therefore not necessarily expect to find a more serious decline in housing starts than what has occurred thus far. The slide is just beginning. To some extent, the adjustment has been a matter of timing, and my estimate is that there is more to come.

To be sure, I do not expect the decline in housing starts to be as great as that in 1974–75 but, at the same time, I do not expect the recession to be as deep as the previous one. Also, nominal mortgage rates in the current inflationary environment do not have the same meaning to the prospective home buyer or landlord as they have on several previous occasions of monetary restriction. The current recession is mixed in several ways; it is not an across-the-board adjustment at this stage, and I am not surprised that residential construction is one of the sectors that shows some strength.

Nevertheless, the authors are, in my opinion, correct in citing three dominant factors that offset recessionary forces in the housing market: the demographics of the "baby boom" generation, the attractiveness of residential real estate as an investment, and the introduction of money-market certificates. I think that demographic factors have been addressed in a reasonable way. As for the two economic factors, I think that the analysis can be fruitfully pushed further.

In today's inflationary environment, real estate values have held up well and most households—young persons and others—can readily see that residential real estate should occupy an important position in their wealth portfolios. A number of interest rates are appropriately introduced as indicators of alternative investment opportunities, but careful investigation of inflation, equity rates, profit rates (incorporated or unincorporated), or other asset rates is not implemented. Reference is made to the unsuccessful testing of real estate rates as explanatory variables in some equations, but that does not satisfy me. I believe that asset-demand functions of households should include the entire spectrum of relevant rates and prices, which is the present tendency in econometric research on systems of demand functions.

A conventional approach—single-equation exploration by ordinary multiple regressions like those in the paper—will understandably have the usual problems of multicollinearity and shortages of degrees of freedom, but parametric specifications of demand systems enable one to deal with these effectively. Extensions of the methods of demand systems to wealth holding can be made.[1] The advantage of this approach is that one can obtain an estimate of the effects among other asset prices or rates and

1. See Mitsuo Saito, "Household Flow-of-Funds Equations: Specification and Estimation," *Journal of Money, Credit and Banking*, vol. 9 (February 1977), pt. 1, pp. 1–21.

home ownership. However, I am troubled by the mixing of real and nominal magnitudes by the authors in their estimated equations, which is particularly misleading today, when one feels intuitively that present high mortgage rates simply are not as much of a deterrent as they would have been in other epochs of their sample period.

The estimated use of the unemployment rate in the home ownership equation 2, and the remark that borrowers "seek the largest loan available based on their collateral" do not seem to me to give an appropriate role to expected income, particularly its adequacy to cover mortgage service costs or other home-operating expenses. There is certainly a limit to the amount of prudent borrowing, accounting for inflation, income, and property value. The estimated equations do not properly address this issue.

The introduction of money-market certificates did have an impact on credit availability for the mortgage market, and they are new phenomena in the current situation. I admire the authors' calculations for isolating their net contribution to the maintenance of the current level of housing demand, but the introduction of money-market certificates was not the only structural change that affected banking by households in the sample period or in the very recent period. Again, in the spirit of looking at the entire problem and not the partial problem of limited single-equation regressions, there should be some assessment of the expansion of NOW accounts (negotiable orders of withdrawal), introduction of electronic funds transfers, money-market funds with check-writing privileges, telephone transfers, and savings accounts with bill-paying privileges. These and similar banking innovations have also had some impact on the mortgage resources of thrift institutions.

The authors correctly reject casual empiricism, which indicates that money-market certificates have helped, and instead provide estimates of magnitudes. Their estimates are sufficiently plausible, and I cannot refute them by substituting another estimate, but I do think that, in accounting for the maintenance of the present level of housing, they may have incorrectly estimated their relationships and possibly attributed more power to money-market certificates than is justified.

Of lesser consequence are some observations on style, methodology, or interpretation. All statistical equations are automatically estimated with correction for first-order serial correlation of residual error, which is somewhat mechanical. Some estimates obtained for serial effects are small. I would have preferred to have seen the estimates without such correction and then to have made a decision on whether to introduce the correction or some other respecification. In dynamic simulations I have often found equations, so corrected, to cumulate error rapidly.

The authors note that two variables were collinear in the estimation of equation 3 and therefore one of the two was dropped from the equation. This seems an arbitrary procedure for dealing with the problem, and it biases the estimate in favor of the variable that was retained.

The discussion of nonprice terms associated with mortgage loans does not seem to me to be appropriate. A sensible price would be the average monthly payment, which can be expressed as a formula in terms of down payments, length of mortgage, and interest rate. Moreover, special "points" charges and repayment penalties can also be formulated as part of the price. Viewed in this way, the so-called nonprice terms are merely different dimensions of price and should be incorporated in the specification as objectively as the more conventional price terms.

General Discussion

Anthony Downs was joined by several other participants in expressing surprise that the real rate of return on housing and the real interest rate on mortgages failed to perform in the equation explaining housing starts. Martin Feldstein suggested that the *after-tax* real rate of interest on mortgages would be a more appropriate variable than the before-tax rate that the authors tried. Lawrence Summers elaborated on the various ways that tax considerations favored investment in owner-occupied housing as an asset. On the other hand, Martin Baily felt that the nominal interest rate on mortgages remained an important determinant of the level of housing demand, because the nominal rate determines the monthly payment. Many borrowers are liquidity-constrained, and many lending institutions compare the monthly payment with the borrower's income to determine credit worthiness. Robert Hall and Franco Modigliani amplified the reasons for believing that the high rate of return on housing is an important stimulus to demand. Hall noted that, on the appropriate after-tax basis, the rate of appreciation on houses far exceeded the interest rate on mortgages. And he felt that the rate of return on housing was reasonably expected to remain higher than that on other assets.

Modigliani felt that the authors had not convincingly answered the crucial question of whether, and to what extent, the recent resiliency in residential construction reflected availability of funds, rather than the high return from houses due to the tax deductibility of interest, the outstanding performance of housing as a hedge against inflation, and the resulting speculative fervor in the housing market. His skepticism about the role assigned to credit availability was reinforced by the fact that, according to the authors' results, most of that effect occurred in the multifamily sector, where it would be least expected.

Arthur Okun asked how the critics who stressed the high rate of return to investment in housing could account for the reasonably good fit of the equation for housing starts in the paper. The authors found no mystery in the behavior of single-family starts before the middle of 1978. In response, Benjamin Friedman argued that it was appropriate to be skeptical of any equation which omitted a class of variables that on theoretical grounds ought to be important, even if it tracks well. Jaffee suggested that the failure of an expected appreciation variable to perform significantly might reflect the fact that the equations were explaining the number of housing starts rather than the real value of the units built. But Feldstein argued that both the real value and the number of units ought to be influenced by the prospective rate of return.

Several suggestions were made for improved specification of the model. John Shoven felt that repayments of existing mortgages should be included as a source of funds in the variable for mortgage availability; he noted that repayments should also respond to variations in interest rates. Peter Clark cautioned that the equations that include both corrections for autocorrelation in the error term and a lagged dependent variable had to be interpreted with care. Clark said that the procedure might lead to an overly long estimated lag in the adjustment coefficient and suggested that other specifications be tried.

James Tobin proposed an alternative approach relying on a stock, asset-demand function to explain the price of existing houses, and then a flow-supply equation to explain how many houses are built by relating these prices to the relevant wages and other construction costs. Dwight Jaffee pointed out, however, that the model was essentially demand driven, because it assumed a constant-cost, horizontal supply function. Jaffee observed that, in fact, the boom in prices for existing houses was not being fully matched by the prices of new units; Kenneth Rosen added that this phenomenon was particularly marked in California. William Fellner also saw the desirability of a stock-demand approach. According to data he had studied, the value of housing as a ratio to disposable income has been rising in nominal terms and falling in real terms. To explain that, one should want to estimate the income elasticity, price elasticity, and importance of expectations of capital gains.

With respect to multifamily units, Feldstein remarked that government programs outside the credit area should be taken into account. In particular, government provision of multiunit housing in the early 1970s might have been important in the bulge and subsequent decline in multifamily starts.

The discussion also highlighted the need for better modeling of the behavior of thrift institutions. Jaffee was receptive to Lawrence Klein's suggestion that the demand of thrift institutions for deposits be modeled in a system of equations. Daniel Brill, Friedman, and Tobin discussed the difficulties of determining the objectives of thrift institutions, since most were not standard profit-seeking corporations.

Several participants felt that, in addition to money-market certificates and federal agency credit, other factors may have been important in sustaining home building in 1978–79. Feldstein mentioned mortgage-backed bonds; Downs, the removal of usury ceilings on interest rates; David Fand, the use of "jumbo" certificates of deposit and commercial paper by the thrift institutions; and Friedman, the heavy investments in mortgages made by the commercial banks. Downs also reported that equal rights legislation had forced lenders to weigh the incomes of both spouses equally, thereby making mortgage credit more readily available to them.

Downs commented that the money-market certificate was one tool of government policy that had clearly succeeded in achieving its objective. But he voiced some concern that the support it provided to the housing market may have added to the inflation rate. John Kareken felt, however, that the misallocation costs caused by the former policies of squeezing the mortgage market had to be weighed against the additional inflation costs. And Feldstein interpreted the money-market certificate as a relaxation of government constraints on financial markets; its effectiveness showed that policy can succeed when it frees markets.