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Authors
Dokko, Yoon
Edelstein, Robert H.
Urdang, E. Scott

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BY

YOON DOKKO

ROBERT H. EDELSTEIN

E. SCOTT URDANG

GRADUATE SCHOOL OF BUSINESS ADMINISTRATION

CENTER FOR REAL ESTATE AND URBAN ECONOMICS
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RESIDENTIAL INVESTMENT AND MORTGAGE MARKETS[†]

by

Yoon Dokko,* Robert H. Edelstein** and E. Scott Urdang***

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*Assistant Professor of Finance, University of Illinois at Urbana-Champaign.

**Professor of Business Administration and Co-Chairman of the Center for Real Estate and Urban Economics, University of California at Berkeley.

***Partner, Laventhol and Horwath, Philadelphia, PA.

RESIDENTIAL INVESTMENT AND MORTGAGE MARKETS

ABSTRACT

This paper develops an empirical model for the 1960-1984 period for examining the impacts of the housing finance system on residential investment (residential construction). Our statistical results strongly support the position that non-interest rate variables affect mortgage activity and housing construction. This finding, the existence of non-price credit rationing, implies that mortgage finance-housing construction models that fail to include non-interest rate variables are seriously misspecified. Though we find a structural change in the housing construction and mortgage markets in the early 1980s, probably attributable to capital markets integration and financial institutional deregulation, non-interest rate terms continue to matter. Hence, credit rationing continues to be an "allocative device" in the housing construction and mortgage markets.

INTRODUCTION

The residential investment (housing construction)[1] and mortgage markets have been, and continue to be, the focus of intense debate in the development of United States economic and social policy. One unresolved issue from these debates is determining the true interrelationship between housing financing and residential investment-housing construction.[2] The objective of our paper is to develop an empirical model using annual data for studying the interrelationship between the real housing sector and the housing finance market.

Our paper is organized into four sections. Section I presents a schematic view of housing-mortgage markets. Section II outlines the empirical model. Section III reports the statistical findings. Section IV discusses the conclusions and implications.

I. CONCEPTUAL FRAMEWORK FOR HOUSING-MORTGAGE MARKETS

Conceptually, we model the housing finance sector and the real housing sector as a stock demand-stock supply general equilibrium model, with stock-flow adjustments for housing construction (i.e., residential investment) and mortgage debt occurring over time. The housing-mortgage markets are represented schematically in Figure I.

(Insert Figure I here)

Beginning at the far right hand side of Figure I, prices, rents and vacancy rates are determined by the interaction of the stock demand for and the stock supply of housing. Housing stock demand depends upon the expected price of housing, the expected price of goods and services in general, and the cost and availability of mortgage credit and tax considerations, all of which determine the real user cost of capital. The real stock demand is affected, also, by real permanent income or wealth and demographic variables.

The real value of the net stock supply of housing depends upon the existing supply of housing, demolitions, removals, additions, real depreciation, and alterations of existing stock, as well as new construction (i.e., recent housing starts). The net addition to the new supply of housing depends upon the interrelationships among expected housing stock prices (and rental rates), vacancy rates and expected costs of construction (including land, financing and other inputs). This is the builders' expected profit-risk decision. The expected cost of construction is determined by earnings of production factors (including costs of labor, materials, construction financing and land inputs) and the current level of residential construction activity itself. The profit-risk decision is impacted also by the level of non-residential real estate activity, a potential competitor for housing production resources.

Moving to the lower half of Figure I, the availability of and terms for mortgage funds on the supply side depend upon the joint interplay among public sector policies, the general capital markets and private sector housing finance institutions. The supply of mortgage credit (or institutional mortgage approvals) depends upon the yield and other non-price mortgage terms[3] vis-a-vis those obtainable on alternative investments, conditional upon the size and expected growth of lender-institutional investment portfolios, the relative mix of mortgage holdings in existing portfolios, the access to the secondary market, and the public sector environment (e.g., monetary and fiscal policies). The derived demand for mortgage credit essentially depends upon the demand for housing services from the housing stock demand.

Hence, our theory posits a linkage between the real housing sector and the financing of housing through the demand for mortgage credit as a function of the stock demand for housing. Furthermore, financing may affect housing supply by affecting builders' profit incentives. These considerations suggest that credit rationing-availability may be important determinants of housing market activity.

II. THE EMPIRICAL MODEL

II.1. Model Summary

(Insert Exhibits I and II here)

The long run equilibrium housing-mortgage financing markets model developed in the previous section is summarized in equation form in Exhibit I, equations (1) through (8). Exhibit II defines all terms and variables.

Since the purchasing and financing of housing are not "marginal" adjustments for most households and/or investors, there is likely to be a difference between desired and actual levels of activities. Hence, our real housing and financial sectors are couched in a stock-flow adjustment framework. That is, α in equation (2) represents the speed of the adjustment, as a function of basic economic variables such as real income, demographic factors and the real user cost of capital. Similarly, β in equation (2) represents the depreciation rate per unit of time; and is assumed to be proportional to the existing housing stock. Finally, γ in equation (6) represents the adjustment coefficient for the difference between desired and actual mortgage stocks; and is assumed to be a function of the change in the mortgage yield and non-price mortgage terms.

(Insert Exhibit III here)

Exhibit III presents the solution of the system of equations (1) through (8) in an estimable form. The equations to be estimated are the flows of housing demand (equation 9), housing supply (equation 10), mortgage demand (equation 11), and mortgage supply (equation 12). All variables, unless otherwise specified, are logarithmic transforms. All flow and stock variables are scaled in real per capita terms to remove the time trend. All interest rate variables are the logarithm of one plus the decimal value.

Two general characteristics of the model are important to note. First, our analysis, based on economic theory, employs real variables as determinants of economic behavior. Though this point seems tautological, in fact, many prior studies have used nominal (or *ad hoc* mixtures of real and nominal) variables in their analyses. Second, our analysis uses annual data based on the Wharton-MPS model or publicly available sources. As such, many of the subtle lag adjustment processes, which may be faster than (or not correspond to) a calendar year, may not need to be considered.

II.2. Equation 9: Housing Demand

Equation (9) is derived by substituting equation (1) into equation (2). The housing flow demand is a function of permanent income (Y^P), the demographic variable (DEMO), the tilt effect ($\widehat{TILT}$), the real user cost of capital for housing services ($\hat{UCOST}$), the lagged real housing stock ($HSTK_{-1}$), and the lagged housing flow demand (H^d_{-1}). ("^" over a variable denotes that it is being treated as endogenous.)

The housing flow, measured by the real value of net residential construction (investment), is used as the dependent variable for the housing demand function.[4] Our model does not distinguish between single-family and multi-family construction. This is contrary to many earlier approaches. We take this position because the shift from rental to owner-occupied units, on both the supply and demand sides, can be accomplished very quickly and with little costs in many cases (e.g., condominium conversions); and it is inappropriate to assume that all multi-family units are rental properties. In equilibrium, the rental value for apartment housing services and the implicit rental value for single-family housing services should equalize the marginal benefits of owning versus renting. Furthermore, it is extreme to assume that production of multi-family housing is strictly supply determined.[5] Many multi-family projects are not started until a substantial portion of the building is "pre-sold," for example, through a syndication; even speculative construction is based on anticipated demand by suppliers.

In general, the explanatory variables for the housing flow demand function are straightforward except for the real user cost of capital ($\hat{UCOST}$), the tilt effect variable ($\hat{TILT}$) and the lagged housing flow demand (H^d_{-1}). While real housing demand should be determined by the real user cost of capital for housing services ($\hat{UCOST}$),[6] nominal variables relating to mortgage financing may play a potentially important role in real estate housing decision-making. If nominal mortgage interest rates rise in response to increases in the anticipated future inflation rate, the real cost of debt services on fixed rate mortgages during the early years of a mortgage will be relatively high. The real initial burdens of high nominal interest rates (or similarly a lower loan-to-value ratio) will cause a set of constraints on housing consumption, thereby reducing effective mortgage demand; and, in turn, potentially affecting observed housing flow demand (consumption). This has been called the "tilt" effect.[7]

The lagged housing flow demand variable (H^d_{-1}) is placed on the right hand side of equation (9), with the hypothesized coefficient $0 < a_6 < 1$, in order to capture a dynamic adjustment path of housing flow demand to a change in the desired housing stock (HSTK*).[8]

II.3. Equation 10: Housing Supply

Housing production-supply is a function of builder profitability ($\hat{PRFT}$), resource constraints on builders (CRD), changes in current income (ΔGNP), the measure of housing vacancy ($\hat{VACN}$) and the housing supply itself lagged one period (H^s_{-1}). The housing flow supply is measured by gross residential investment, which differs from net residential investment (the measure of housing flow demand) by depreciation. We use this distinction because the flow supply relates to decisions about gross production, while stock demand adjustments should relate to net changes in the stock caused by net production.

The residential construction industry is competitive; hence, activity should be a function of expected profitability, adjusted for risks. To capture these notions, we have created a builders' expected profitability index ($\hat{PRFT}$), defined as the ratio of the expected housing stock price to the index of current construction costs. The construction cost index is a weighted average of the Boeckh index (which measures the costs of materials and labor, but not land or capital) and the prime rate (which is a reasonable surrogate for both builder capital costs and land input holding costs). The measure of housing vacancy ($\hat{VACN}$) is included as a control for risks.

Do resource constraints affect housing supply? Guttentag (1961) stressed the importance of supply conditions and the essentially counter-cyclical nature of residential construction investments as a function of "residual" resource availability to builders. According to this hypothesis, housing producers are unable to compete for resources with other sectors, and will be a residual claimant on resources in the economy; therefore, construction will tend to decrease (increase) when the economy reaches high (low) points in general economic activity because resources tend to be (not) used elsewhere in the economy.

A surrogate for the "tightness" of credit and other resources is the spread between the short term interest rate (3-month Treasury bill rate) and the long term interest rate (10-year Treasury bond rate). In general, short rates rise relative to long rates during economic booms, and fall during economic downturns; the rate differential mirroring the pattern of credit and other resource availability.[9,10]

The long run stock demand for housing is determined by permanent income or wealth. In this way, current income is only a small portion of the explanatory variable used in the housing stock demand.

However, changes in current income (ΔGNP) are likely to be a short-run determinant of residential construction.[11] If builders start their plans during a recession (a fairly likely occurrence), and if income begins to rise rapidly, builders may modify original plans by either adding more expensive options or speeding up existing construction; and *vice versa* for declining income periods. Thus, changing income with no lag or a very short lag (probably less than a year) may be a relevant variable in the residential construction supply equation as long as it is used as a "modification variable," and not as a long run determinant of supply. In this role, current income primarily affects the value of housing rather than the number of units constructed; our dependent variable is the *value* of the supply of residential construction, and, therefore, is likely to require current income as an anticipation-modification explanatory variable.

The lagged housing flow supply (H^S_{-1}) is included because housing construction, especially in the multi-family market, can take more than one year to build out. The coefficient of H^S_{-1} is anticipated to be in the unit interval to capture dynamic impacts.

II.4. Equations 11 and 12: Demand and Supply of Mortgage Loans

In our framework of demand-supply equilibrium for the mortgage market, changes in mortgage interest rates would be generated by fluctuations in the underlying markets; housing activity on the demand side (through changes in real variables such as real user costs and the real cost of capital for builders and long-term owners, and so forth) and deposit flows on the supply side. Because housing activity and deposit flows fluctuate a great deal, one might expect *a priori* strong movements in mortgage interest rates compared with other capital market interest rates. Historically, however, mortgage interest rates have been sluggish, moving more slowly than other interest rates in the capital market. It is likely that institutional and regulatory factors[12] provide important explanations for this phenomenon.

Sluggish changes in mortgage interest rates suggest that the "pure price" variable in the mortgage markets may <u>not</u> be the only mechanism for market clearance. When the mortgage interest rate does not rise rapidly in the presence of excess demand in the mortgage market, "non-price rationing" may be used to allocate supply.[13] The nature of this allocation varies, depending on a variety of factors. In extreme cases, mortgage loans may not be available on any terms. More commonly, variations in the non-price terms of the mortgage loan contract may play a role. For example, reductions in the loan-to-value ratios are supposed to be common in periods of tight money; they serve to ration credit first by reducing the amount of the loan borrowers can receive, and second by eliminating some potential borrowers who require loans with low downpayments. Variations in maturities, prepayment penalties, and other non-price terms can operate in a similar way to reduce "effective" demand. In reality, so-called non-price terms have an economic equivalence of interest rate changes, and act to alter demand (see, also, footnote 3).

On the mortgage supply side, three interest rates are important: the interest rate charged for mortgage loans ($\widehat{YLD}$), yields available on alternative non-mortgage assets (RLONG), and the cost of funds to lending institutions ($\widehat{CFUND}$). In the empirical specification of the mortgage supply function, because these interest rates are highly correlated, we use the yield differential ($\widehat{\text{YLDDIF}}$, the mortgage interest rate ($\widehat{\text{YLD}}$) minus the long term interest rate (RLONG)) and the cost of funds ($\widehat{\text{CFUND}}$) only. On theoretical grounds, lending institutions making portfolio allocation decisions should examine the real yield differential between mortgages and alternative instruments. To the extent $\widehat{\text{YLDDIF}}$ includes an appropriate risk differential, other non-price mortgage terms (such as the loan-to-value ratio or mortgage maturity) need not be included in our analysis. Finally, both thrift institutions savings flows ($\widehat{\text{SFLO}}$) and governmental mortgage market activity (CAM) may be important determinants of mortgage flow supply.

On the mortgage demand side, real interest rate variables should also be important. In a stock-flow adjustment model, *changes* in real mortgage interest rates (rather than the absolute level) may cause *changes* in mortgage *stock* demand.[14] We use the change in the real mortgage rate ($\Delta\widehat{\text{YLD}}$) as an explanatory variable for the mortgage flow demand.

Traditional non-price terms may be important determinants of mortgage demand. The tilt effect ($\widehat{\text{TILT}}$), a composite variable, is the product of the loan-to-value ratio, the real price of housing and the expected inflation rate, divided by real permanent income. The expected inflation rate should be related to the level of *nominal interest rates* to mortgage borrowing. Hence, the $\widehat{\text{TILT}}$ variable is a measure of the household mortgage payment burden. Since $\widehat{\text{TILT}}$ contains the loan-to-value ratio, $\widehat{\text{LV}}$ is omitted as a separate explanatory variable.

Since the demand for mortgages is derived from the housing stock demand, the change in the housing stock (ΔHSTK) should be included in the mortgage demand function. Transaction and information costs associated with the issuance of mortgages are relatively expensive. Hence, one would expect an adjustment process between optimal and actual levels of mortgages demanded. For these reasons, a stock-flow adjustment model is used for the mortgage demand function, with the lagged mortgage stock ($MSTK_{-1}$) included as an explanatory variable.

III. EMPIRICAL RESULTS

(Insert Table 1 here)

Table I contains Three-Stage Least Squares regression results[15] for (i) the housing demand function (equation 13), (ii) the housing production supply function (equation 14), (iii) the mortgage loan demand function (equation 15), and (iv) the mortgage loan supply function (equation 16). Equations (13) through (16) correspond to the system of equations (9) through (12) in Exhibit III.

Our empirical results, while reinforcing many of the findings of earlier studies, represent research improvements since our analysis simultaneously utilizes real economic variables, takes into account the possibility of the cross-equation correlation as well as variable simultaneity in housing and mortgage markets, and measures coefficient estimates for explanatory variables in each market within the context of the theoretically appropriate stock-flow adjustment model.

An important issue to be examined in our empirical analyses is the stability of the real housing and mortgage finance system. During our sample period, 1960 through 1984, many innovations and changes have occurred in mortgage markets, especially since the late 1970's. It is an open question whether either the wide use of new mortgage instruments or the integration of the housing finance system into general capital markets has had a discernible impact upon real housing consumption-production or real mortgage demand-supply. For this reason, our analyses have been sub-divided into two periods, 1960-1984 and 1960-1981.[16]

III.1. Housing Demand Function (Equation 13)

The most important explanatory variable for the housing demand function is the real user cost of capital ($\hat{UCOST}$); as expected, the coefficient for $\hat{UCOST}$ is statistically significantly negative. Permanent income (Y^P) and the demographic variable (DEMO) do have the anticipated statistically significant positive coefficients. The coefficient of the lagged stock of housing ($HSTK_{-1}$), which is expected to have, ceteris paribus, a negative impact on the net flow demand for residential housing, is statistically significantly negative. The presence of the lagged value of housing demand (H^d_{-1}) as an explanatory variable (with hypothesized coefficient value inside the unit interval) corresponds to a plausible dynamic adjustment path for the housing demand flow to a change in the housing stock demand.[17]

The anticipated negative coefficients of $\hat{TILT}$ are statistically significant for the 1960-1981 time period, but insignificant for the 1960-1984 time period. The latter result is not inconsistent with the claim that real housing consumption, controlling for user costs, is affected by changes in mortgage conditions. Rather, it could be argued that these statistical results should be expected because the widespread introduction of alternative mortgage instruments in the late 1970's and early 1980's was designed specifically to ameliorate the "tilt" effect.[18] Also, it is claimed that in the early 1980's the housing finance system became integrated into general capital markets. The modified Chow-Fisher test for the stability of the housing demand equation is statistically significant, suggesting the 1982-1984 time period is statistically different from the early 1960-1981 time period. This finding is consistent with the change in the impact of the tilt effect and the capital markets integration hypotheses.

III.2. Housing Supply Function (Equation 14)

The housing supply equation contains especially pleasing results. Its statistical results are robust, conforming to our theoretical hypotheses, and are markedly better than several prior studies.[19] An important feature of our housing supply function is, as discussed in the previous section, that credit-resource availability (CRD, the difference between long term and short term interest rates) is an important determinant of housing construction activity; the coefficient of CRD is positive and statistically significant. This finding indicates that Guttentag's (1961) residual user hypothesis may be still operative in the economy.

As expected, the coefficient of the builder profitability index ($\widehat{PRFT}$) is positive and statistically significant. The change in current income (ΔGNP) is a surrogate adaptive-modifier variable; and its coefficient is statistically significantly positive. Housing vacancy ($\widehat{VACN}$) plays an important role in determining housing supply activity as indicated by the statistically significantly negative coefficient estimate. The coefficient of the lagged flow supply variable (H^s_{-1}) is statistically significantly positive in the anticipated unit interval.[20] Finally, the housing production supply function does not seem to have shifted during the 1960-1984 sample time period; the Chow-Fisher test is statistically insignificant.

III.3. Mortgage Demand Function (Equation 15)

An important finding about the mortgage demand function is that non-interest rate terms do matter. First, the coefficient of $\hat{TILT}$, as it is in the real housing flow demand function, is statistically significantly negative. Second, the coefficient of the mortgage maturity ($\hat{MT}$) is positive and statistically significant. These combined findings for $\hat{TILT}$ and $\hat{MT}$ may imply that housing consumption is affected by financing; and, specifically, the optimal level of financing for the housing stock is affected by real payment "burdens." To the extent this model is appropriately specified, housing mortgage market models that exclude non-price mortgage terms may be seriously misspecified.[21]

As discussed before, the mortgage demand function is expected to be a stock-flow adjustment model. Changes in optimal demand for the mortgage stock may require significant lags before adjustments take place. The coefficient for the $MSTK_{-1}$ variable is, as expected, negative and statistically significant. The real housing flow variable ($\Delta HSTK$) does have the anticipated positive coefficient, and is statistically significant. This latter result provides justification for examining mortgage demand as a function of the housing stock in a partial adjustment framework. Finally, changes in the real mortgage yield ($\Delta\hat{YLD}$), as expected from household portfolio considerations, have, ceteris paribus, a statistically significant negative impact upon demand.

On balance, the results for the mortgage demand function are robust; but the Chow-Fisher test indicates that the underlying regime for the 1960-1981 time period is different from that of the 1982-1984 time period. This is consistent with the hypothesis that the housing finance system has changed as a result of the growth in the use of alternative mortgage instruments and/or the integration of the mortgage finance market into general capital markets. However, it is important to note that while the Chow-Fisher test implies a split in the "regimes," the variable-by-variable qualitative results are substantively the same for the entire sample period.

III.4. Mortgage Supply Function (Equation 16)

The mortgage supply function performs adequately, but less well than the other equations in our system. For the 1960-1981 time period, increases in the real mortgage yield over the long term real interest rate ($\hat{YLDDIF}$) have a statistically significant positive effect upon mortgage supply. For the entire 1960-1984 time period, however, the coefficient of $\hat{YLDDIF}$ is not statistically significant with a negative sign.

There are at least three plausible explanations for this statistical finding. First, during the early 1980s, lenders were either reluctant or unable to originate mortgage loans because they faced a changing environment characterized by financial institution disintermediation, intensified deregulation, and increased general economic and capital market uncertainty.

Second, lenders in more recent times do less long-term holding of mortgage loans in their own portfolios, and tend to dispose of mortgages in the secondary markets. In effect, lenders earn income from origination fees and perhaps loan servicing; and as long as they have a conduit for selling mortgages at current rates, they may not worry about the relative yields on mortgages versus other assets. Indeed, over the past three decades the differential between mortgage yields and long term interest rates has diminished secularly.

Third, two other major determinants of the mortgage supply function, the cost of funds to lenders ($\widehat{CFUND}$)[22] and the savings flow ($\widehat{SFLO}$), may cause the yield differential to be less important. When $\widehat{SFLO}$ is omitted from the mortgage supply equation, the coefficient of $\widehat{YLDDIF}$ becomes positive, and its statistical significance improves; while the overall performance of the equation diminishes significantly.[23]

The inclusion of either non-price mortgage terms (such as the loan-to-value ratio or the mortgage contract maturity) or the lagged mortgage stock[24] in the mortgage supply function does not affect statistically the mortgage supply. These findings would be consistent with a mortgage supply market, where interest rate adjustments are sufficient to clear the supply side of the market even though the current cost of funds and the level of savings flow are important. Finally, federal credit agencies' mortgage commitments (CAM), controlling for the yield differential, cost of funds and savings flow, do not appear to statistically affect the mortgage supply function.[25]

IV. CONCLUSIONS AND IMPLICATIONS

This paper has developed a model that integrates the real housing sector and the mortgage market sector into an empirically estimated system of equations. In general, our empirical findings are robust and consistent with theory, suggesting that the stock-flow partial adjustment framework is an appropriate way to model the housing-mortgage markets.

Our most important finding is that non-price housing-finance variables influence resource allocation in at least three places in housing-mortgage markets. Resource availability (i.e., the residual user hypothesis) appears to affect production decisions in the real housing supply sector. Non-price mortgage variables, including the tilt effect appear to affect the willingness and ability of borrowers to demand mortgages, and impact on real housing demand decisions. It should be emphasized that our model is an equilibrium model; hence, our findings confirm that non-price variables purportedly clear the market, and a disequilibrium analysis is not necessarily required for either real or financial sectors.

Second, our results imply credit availability does matter, and structural estimates for the real housing and mortgage finance markets which fail to include non-interest credit terms or other non-price variables may be seriously misspecified. More broadly speaking, the transmission channels, by which monetary policy affects the economy through interest rate impacts on residential investment decision-making, may require the inclusion of these transmission effects working through non-interest rate and resource availability variables.

Third, subject to additional analysis, this study lends support to those who argue stringent monetary policy is "discriminatory" against borrowers seeking low down-payment loans. To the extent that low down-payment (i.e., high loan-to-value ratio) borrowers are relatively asset poor, it can be concluded that tight monetary policy may have differential impacts within the mortgage market itself. The incidence of such impacts will most frequently fall on borrowers with low non-human wealth positions.

Fourth, it is commonplace to argue that the housing finance system has become integrated into general capital markets, increasing capital market (allocational) efficiency. We find a "structural" change in the real housing and mortgage sectors in the early 1980's, probably related to capital market integration. However, our findings simultaneously suggest that non-price terms did matter in the past (and continue to matter through 1984) in the production of housing and the demand for mortgage credit. These latter results may imply that "credit rationing" continues to be an "allocative device" in the housing system.

FOOTNOTES

[1]We use the terminology residential investment and housing construction interchangeably in this paper.

[2]See, for example, Kearl, Rosen and Swan (1975) and Friedland and Macrae (1978, especially Section III) for various modeling approaches and problems.

[3]The distinction between "price" (i.e., interest rates) and "non-price" mortgage terms is misleading; changes in so-called "non-price" terms by affecting the real payment schedules of mortgage contracts are in fact merely different dimensions of interest rate price and/or risk, and, if important, need to be incorporated into model specification. The explanations for non-price terms in the mortgage contracts are numerous and varied. See Baltensperger (1978) for a market-clearing argument. See Guttentag (1961), Hodgman (1960, 1961), Jaffee (1971), Kent (1980), Ostas and Zahn (1975) and Vernon (1965) for varied non-price rationing arguments. More recently, Bester (1985), Jaffee and Russell (1976), Stiglitz and Weiss (1981), and Wette (1983) argue that imperfect information in lending markets leads to the use of non-price terms in mortgage markets.

[4]The conventional use of the number of housing starts <u>units</u> cannot account for <u>quality</u> (i.e., value) changes in the housing stock.

[5]For example, Jaffee and Rosen (1979) state that the demand side determines housing starts in the market for single-family units while the supply side determines starts in the market for multi-family units.

[6]See Hendershott (1980) for a discussion of user cost. Our analysis employs the MPS-Wharton Model user cost variable, which is a weighted average of single-family and multi-family user costs.

[7]See Lessard and Modigliani (1975) for a detailed statement about the tilt effect; see, also, Edelstein and Guttentag (1977).

[8]The dynamic path adjustment should slowly build to a peak (because of supply considerations) and then fall back towards (and possibly oscillate around) the long run impact. Without the lagged value, the initial response of housing flow demand would be at its peak, and then would diminish as the actual stock approaches the desired stock.

[9]The rate differential has been a standard measure of resource availability. See Evans (1969, Ch. 7) for discussion.

[10]We employed two other measures of resource availability: (i) the ratio of investment in plant and equipment to GNP as a "catch-all" measure of resource availability to housing production (this measure

has been also suggested by Evans (1969)), and (ii) net deposit flows (this variable is a direct measure of funds availability and credit tightness). The empirical results are almost identical, irrespective of the measure of resource availability used.

[11]For example, see Klein and Goldberger (1955).

[12]It might be argued that this behavior could be the result of stabilizing interventions by federal agencies; but sluggish movements of interest rates on mortgages have been evident in the United States at least since the beginning of this century, long before federal agencies existed.

[13]Over the last three decades, with the trend towards the "integration" of financial markets, the supply of mortgage lending has become increasingly elastic with respect to interest rates (see, for example, Edelstein and Friend (1976) and Hendershott and Villani (1980)). The supply side for new mortgages as well as the stock of existing mortgages are likely to achieve equilibrium adjustments within a year, the unit time period for this study. Of course, equilibrium might be reached through adjustments in non-price mortgage terms as well.

[14]Muth (1986) argues that changes in (not absolute levels of) interest rates matter in mortgage markets.

[15]Each equation of the system is over-identified. Also, as expected, cross-equation correlations exist, justifying our use of a system's method of estimation, three-stage least squares. Appendix A contains the cross-equation correlation matrices.

[16]See Buckley and Gross (1985).

[17]Omission of the lagged housing flow demand variable has minor impact on the overall results for this equation.

[18]See, for example, Lessard and Modigliani (1975) and Bruckner and Follain (1987).

[19]For example, see Arcelus and Meltzer (1972).

[20]Even though our model uses annual data, the overall performance of the housing supply equation diminishes significantly if the lagged housing supply variable is omitted. This suggests that the builder-supply response lag structure is important for our modeling purposes.

[21]Arcelus and Meltzer (1972) and Muth (1986) argue that price variables can be used exclusively to explain mortgage demand; our analysis is in disagreement with this position.

[22]The statistically significantly negative coefficient of $\hat{CFUND}$ for the 1960-84 time period appears to be consistent with the hypothesis, suggested earlier by Rosen and Jaffee (1979), among others, that mortgage lenders are responsive to the cost of funds (controlling for real mortgage yields and savings flow).

[23]The regression result, excluding $\hat{SFLO}$, for the mortgage supply function in our system of equations is:

$$M^s = \text{const} + \underset{(0.969)}{1.791}\ \hat{YLDDIF} - \underset{(-0.405)}{0.141}\ \hat{CFUND} - \underset{(-1.736)}{0.163}\ CAM$$

$$R^2 = 0.189 \qquad (1960\text{-}1984) \qquad \text{(F-23)}$$

[24]The following regressions show that the effect of the lagged mortgage stock in a stock-flow adjustment model is also statistically insignificant:

$$M^s = \text{const} + \underset{(0.340)}{0.515}\ \Delta\hat{YLD} - \underset{(-1.449)}{1.890}\ \Delta\hat{CFUND} + \underset{(2.499)}{0.319}\ \hat{SFLO}$$

$$- \underset{(-3.027)}{0.154}\ CAM - \underset{(-1.066)}{0.017}\ MSTK_{-1}$$

$$R^2 = 0.769 \qquad (1960\text{-}1984) \qquad \text{(F-24-a)}$$

$$M^s = \text{const} + \underset{(0.694)}{1.003}\ \Delta\hat{YLD} - \underset{(-1.849)}{2.302}\ \Delta\hat{CFUND} + \underset{(3.411)}{0.388}\ \hat{SFLO}$$

$$- \underset{(-2.878)}{0.144}\ CAM$$

$$R^2 = 0.764 \qquad (1960\text{-}1984) \qquad \text{(F-24-b)}$$

The Chow-Fisher F-statistics indicate that there is no structural shift in equations (F-24) for the 1982-1984 time period.

[25]While federal housing credit agency activities are likely to affect housing financing supply conditions (and may be endogenous determinants because policy makers react to market conditions), it is beyond the scope of our simple model. For examples of housing financing and policy-making models, see Jaffee and Rosen (1978) and Goldfeld, Jaffee and Quandt (1980).

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Figure I
HOUSING-MORTGAGE MARKETS MODEL

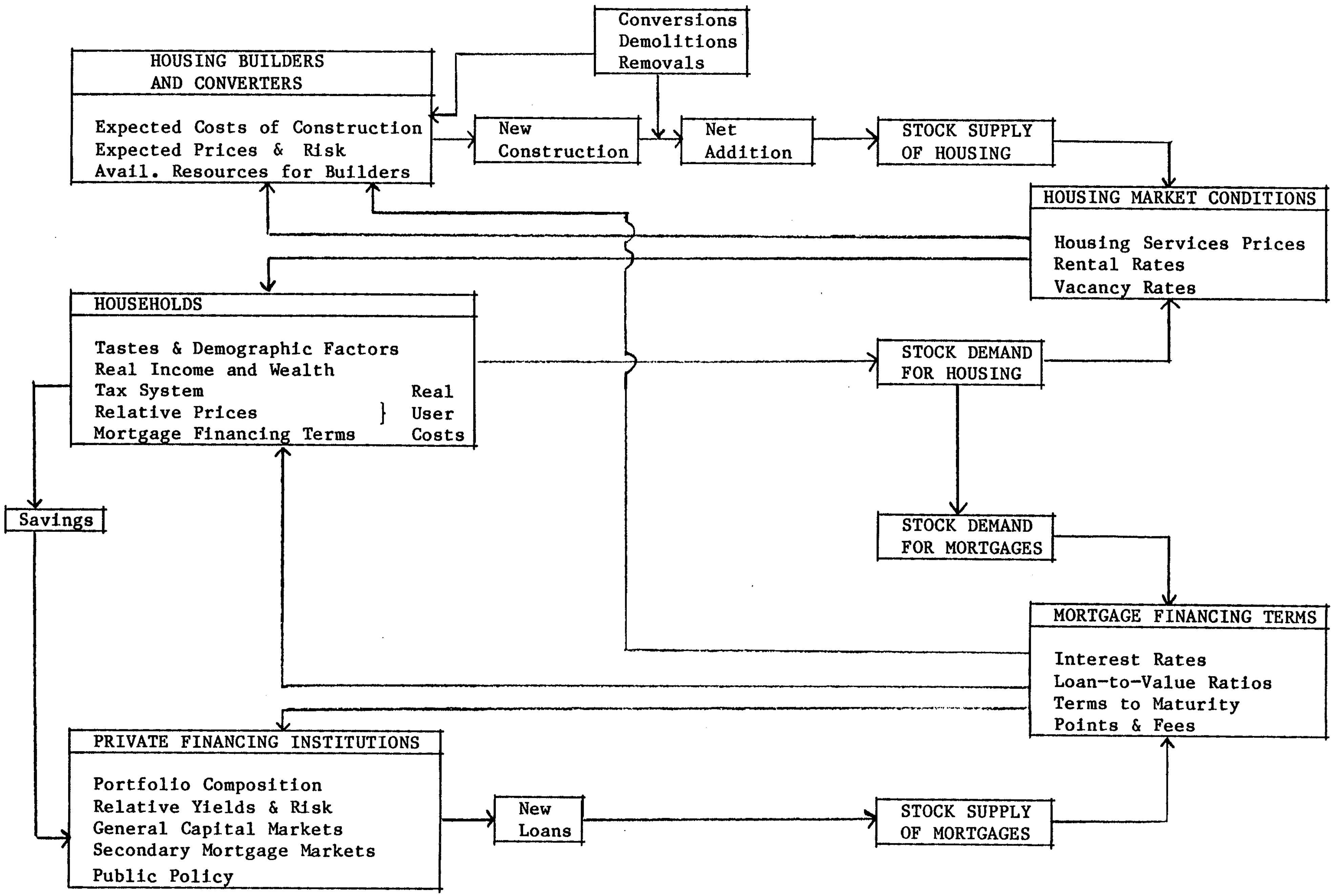

EXHIBIT I

HOUSING-MORTGAGE MARKETS MODEL

A. Real Housing Sector

(1) $HSTK^* = HSTK^*(Y^p, DEMO, UCOST)$

(2) $H^d = \alpha(HSTK^* - HSTK_{-1}) + \beta HSTK_{-1}$

(3) $H^s = H^s(PRFT, VACN, \Delta GNP, CRD, H^s_{-1})$

(4) $H^d = H^s$

B. Housing Financial Sector

(5) $MSTK^* = MSTK^*(YLD, LV, MT, HSTK^*)$

(6) $M^d = \gamma(MSTK^* - MSTK_{-1})$

(7) $M^s = M^s(YLD, RLONG, CFUND, SFLO, CAM, LV, MT)$

(8) $M^d = M^s$

EXHIBIT II

GLOSSARY OF TERMS AND VARIABLES

(i) $\Delta X = X - X_{-1}$

(ii) superscript * denotes for the "desired" level.

(iii) "^" over a variable denotes that it is being treated as endogenous.

(iv) all variables, unless otherwise specified, are logarithmic transforms.

(v) data source is in the bracket:
[1] - the Wharton-MPS model.
[2] - Economic Report of the President, 1986.
[3] - Federal Reserve Bulletin, various issues.
[4] - the Statistical Abstract, various issues.
[5] - Livingston Surveys.
[6] - Federal Home Loan Bank Journal, various issues.

HSTK = per capita real value of housing stock [1].

Y^P = per capita real permanent income, measured by per capital real personal consumption expenditures [2].

DEMO = demographic variable, portion of population in 25-44 age group [2].

PDOT = the expected annual inflation rate [5].

NYLD = nominal mortgage interest rate [3].

$\widehat{YLD}$ = NYLD - PDOT, real mortgage interest rate.

$\hat{P}_h$ = real housing asset price [3].

$\widehat{LV}$ = non-price mortgage term, average mortgage loan-to-value ratio [3].

$\widehat{MT}$ = non-price mortgage term, average mortgage maturity in the number of years [3].

$\widehat{TILT}$ = "tilt" effect variable, measured by the "raw" value of PDOT times $(\widehat{LV} + \dot{\hat{P}}_h - Y^P)$.

EXHIBIT III

ESTIMATION OF THE SYSTEM EQUATIONS

(9) $$H^d = a_0 + a_1 Y^p + a_2 \text{DEMO} + a_3 \hat{\text{TILT}} + a_4 \hat{\text{UCOST}} + a_5 \text{HSTK}_{-1} + a_6 H^d_{-1}$$

(10) $$H^s = b_0 + b_1 \hat{\text{PRFT}} + b_2 \text{CRD} + b_3 \Delta\text{GNP} + b_4 \hat{\text{VACN}} + b_5 H^s_{-1}$$

(11) $$M^d = c_0 + c_1 \Delta\hat{\text{YLD}} + c_2 \hat{\text{TILT}} + c_3 \hat{\text{MT}} + c_4 \Delta\text{HSTK} + c_5 \text{MSTK}_{-1}$$

(12) $$M^s = d_0 + d_1 \hat{\text{YLDDIF}} + d_2 \hat{\text{CFUND}} + d_3 \hat{\text{SFLO}} + d_4 \text{CAM}$$

TABLE 1

3SLS RESULTS FOR THE SYSTEM EQUATIONS (9) THROUGH (12)

(13) <u>Housing Flow Demand</u> (Equation 9)

1960–1984: ($R^2 = 0.81$)

$$H^d = \text{const} + \underset{(5.47)}{6.35}\, Y^P + \underset{(2.15)}{1.51}\, \text{DEMO} - \underset{(-0.77)}{0.11}\, \hat{\text{TILT}} - \underset{(-5.97)}{21.06}\, \hat{\text{UCOST}} - \underset{(-3.85)}{7.14}\, \text{HSTK}_{-1} + \underset{(3.48)}{0.32}\, H^d_{-1}$$

1960–1981: ($R^2 = 0.87$)

$$H^d = \text{const} + \underset{(7.63)}{7.00}\, Y^P + \underset{(2.41)}{1.05}\, \text{DEMO} - \underset{(-4.30)}{0.43}\, \hat{\text{TILT}} - \underset{(-6.00)}{14.54}\, \hat{\text{UCOST}} - \underset{(-5.04)}{6.47}\, \text{HSTK}_{-1} + \underset{(4.98)}{0.40}\, H^d_{-1}$$

Chow-Fisher F Statistic = 9.56 (> 4.15)

(14) <u>Housing Flow Supply</u> (Equation 10)

1960–1984: ($R^2 = 0.81$)

$$H^s = \text{const} + \underset{(2.37)}{0.36}\, \hat{\text{PRFT}} + \underset{(2.25)}{4.04}\, \text{CRD} + \underset{(5.41)}{2.88}\, \Delta\text{GNP} - \underset{(-2.81)}{0.27}\, \hat{\text{VACN}} + \underset{(8.16)}{0.79}\, H^s_{-1}$$

1960–1981: ($R^2 = 0.83$)

$$H^s = \text{const} + \underset{(2.34)}{0.31}\, \hat{\text{PRFT}} + \underset{(2.94)}{4.70}\, \text{CRD} + \underset{(5.27)}{2.84}\, \Delta\text{GNP} - \underset{(-2.36)}{0.21}\, \hat{\text{VACN}} + \underset{(8.69)}{0.83}\, H^s_{-1}$$

Chow-Fisher F Statistic = 2.60 (< 4.08)

TABLE I (cont'd.)

(15) <u>Mortgage Flow Demand</u> (Equation 11)

1960-1984: $M^d = \text{const} - \underset{(-3.64)}{0.91\ \Delta\hat{YLD}} - \underset{(-4.83)}{0.05\ \hat{TILT}} + \underset{(6.84)}{0.94\ \hat{MT}} + \underset{(2.60)}{1.00\ \Delta HSTK} - \underset{(-2.65)}{0.10\ MSTK_{-1}}$

($R^2 = 0.87$)

1960-1981: $M^d = \text{const} - \underset{(-2.86)}{0.69\ \Delta\hat{YLD}} - \underset{(-2.87)}{0.03\ \hat{TILT}} + \underset{(9.75)}{0.97\ \hat{MT}} + \underset{(3.23)}{1.09\ \Delta HSTK} - \underset{(-3.82)}{0.17\ MSTK_{-1}}$

($R^2 = 0.91$)

Chow-Fisher F Statistic = 4.43 (> 4.08)

(16) <u>Mortgage Flow Supply</u> (Equation 12)

1960-1984: $M^s = \text{const} - \underset{(-0.08)}{0.10\ YL\hat{D}DIF} - \underset{(-2.30)}{0.56\ CF\hat{U}ND} + \underset{(5.67)}{0.55\ S\hat{F}LO} - \underset{(-0.38)}{0.02\ CAM}$

($R^2 = 0.66$)

1960-1981: $M^s = \text{const} + \underset{(1.99)}{4.30\ YL\hat{D}DIF} - \underset{(-1.20)}{0.40\ CF\hat{U}ND} + \underset{(2.61)}{0.34\ S\hat{F}LO} - \underset{(-0.29)}{0.02\ CAM}$

($R^2 = 0.64$)

Chow-Fisher F-Statistic = 0.89 (< 4.01)

Footnotes:

[1]t-statistics are in parentheses below the coefficient estimates.

[2]The Chow-Fisher F statistic is a test for the system stability between the two periods, with the critical values at the 5 percent significance level in parentheses.

APPENDIX A

CROSS-EQUATION CORRELATION MATRICES

A. 1960-1984

	H^d	H^s	M^d	M^s
H^d (eq. 13)	1.000			
H^s (eq. 14)	0.728	1.000		
M^d (eq. 15)	0.246	0.248	1.000	
M^s (eq. 16)	0.327	-0.073	0.524	1.000

B. 1960-1981

	H^d	H^s	M^d	M^s
H^d (eq. 13)	1.000			
H^s (eq. 14)	0.883	1.000		
M^d (eq. 15)	-0.075	0.024	1.000	
M^s (eq. 16)	0.152	-0.027	0.590	1.000