Preliminary Development of a Simultaneous Equation Model of an Urban Housing and Mortgage Market**

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Introduction

This paper summarizes the state of development of an aggregative simultaneous equation model of the housing and mortgage markets in New Castle County, Delaware. Unfortunately, the development has not been completed at this time. Thus we will simply report on the current status of the model. In the first section we briefly and inadequately indicate the substantial debt we owe to existing theory and previous authors for the theoretical foundations of the model. In the second section the specific approach to modeling the housing and mortage markets in New Castle County is described. Included here are the accommodations with data constraints that have been found necessary. The accounting framework for the model is also clearly specified. The third section briefly describes the results of estimating the model's equations and preliminary results of attempting to use it for simulation experiments.

Theoretical Foundations

Ours is an aggregative model of housing and mortgage markets much in the tradition of Muth's work as exemplified in (15). Our focus on the mortgage market differentiates us slightly from muth as does our focus on a small geographic region. In these respects we found ourselves following closely the work of Field and Pfister (6).

The variables we wish to explain (and ultimately predict) are prices and quantities of

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** This paper was prepared for presentation at the American Real Estate and Urban Economics Association Meetings, Chicago, Illinois, August 30, 1978.

housing and mortgages. We disaggregate the model reported in this paper to recognize the essential durability of housing, which has also been emphasized by Muth, by dealing both with the stock of housing and the flow of new and renovated or rehabilitated units into it and the demolitions which reduce it. The very existence of a durable stock forces the model to be dynamic.

We also recognize the need to disaggregate in other dimensions and will be doing so in the near future. For example, we will distinguish between single family homes and units built as part of multi-family structures as many authors have done. We will also recognize the importance of intraregional locational forces by disaggregating into central city and suburbs.

While the model presented is aggregative in nature, we have not ignored the micro-economic foundation of the housing and mortgage markets. The variables appearing in the housing and mortgage demand functions recognize the utility maximizing behavior of individual households in the face of budget constraints. The household is assumed to purchase housing both as a source of the consumption goods, housing services, and to obtain the investment goods, housing. The household demand for each of these goods is then influenced by the usual variables: their own prices, the prices and availability of substitutes, the household's income, expectations about future states of the market, and the household's preferences which may or may not be independent of other households. This statement ignores the considerable literature on the importance of detailed housing, household and neighborhood characteristics in determining demand. However, as already indicated, ours is a quite aggregative model at the present time. In aggregating we also lose direct touch with the taste variable but gain a need to measure the number of households. On the supply side of the housing market we recognize that builders are influenced by prices, cost factors and the resultant rate of return on housing relative to that available from the next best alternative. Mortgage lenders are similarly influenced by alternative rates of return as well as the availability of loanable funds. The paragraphs in Appendix A provide silghtly more detail in our view of the theory of housing and mortgage markets.

Specifcation of the Model Equations

Important factors to be considered in formulating housing and mortgage market models in urban areas were described in the preceding section. Constraints and problems encountered in applying the theoretical framework developed to empirical data for New Castle

County, Delaware are described in this section. The major constraint is the limited number of degrees of freedom which results from the unavailability of long time series on housing variables for the region. The Division of Housing in the State of Delaware has issued its *Quarterly Review of Housing Construction* only since 1973. Thus the model is estimated with only 20 or 21 degrees of freedom, depending upon whether or not a lagged variable is specified.

The consequences of a limited number of degrees of freedom are both a reduction in the statistical reliability of estimated coefficients and a reduction in the number of explanatory variables which can be specified in any equation. These effects tend to make the New Castle County model use relatively few variables for each equation, avoid lag structures for the explanatory variables, and focus on capturing major turning points rather than every aberration in housing and mortage market behavior. The constraint will be mitigated in future work by separating the markets of New Castle County into those of the City of Wilmington and its suburbs. This separation will not only increase the numbers of degrees of freedom but will also provide opportunities to consider the locational aspects of the markets which are not treated in this paper.

In addition to data problems related to the lengths of time series, there are also monumental problems regarding the availability of data for the geographic area in question, New Castle County, Delaware. One could argue that modeling such an area is not worthwile both because of data limitations and because the area does not really constitute a housing market. However, the statistical units for which more data are available (e.g., the Wilmington SMSA, the Philadelphia-Trenton-Wilmington SCA, the State of Delaware) also do not constitute a housing market. Thus the approach we have chosen to follow is to use those measures for New Castle County that are available and to substitute the next best area for data not available on a county basis. In doing this we assume that variations in many housing market variables will be similar in New Castle County and in the larger region.

Housing production volume is measured by the number of building permits issued. The building permits data used do not include new units financed and/or insured by the Federal Housing Administration, the Farmers Home Administration, the Federal Department of Housing and Urban Development, or the Veterans Administration. The number of mobile homes is not explicitly considered due to data inconsistencies. Publicly-assisted housing construction is considered as an exogenous factor which usually has different

demand and supply behavior from that of the private housing market as mentioned before.

Housing activity is measured by housing units in such a manner that each apartment unit in an apartment building is counted as one housing unit. The possible measurement inaccuracy by using housing units as the unit of stock instead of using value or the number of rooms may be alleviated in future work by separating new housing construction into single-family and multi-family units. The equations describing the housing market in our model appear below. The accounting identity, (1), for the stock of housing provides the basis for the model. Identity (1) distinguishes between the private and the public parts of the stock. We assume that the public stock is exogenously determined, even though we recognize that the market forces which lead to inadequate supplies for lower income families at prices they can afford ultimately induce public action in the housing market. We feel, however, that the decision to produce publicly assisted housing is not closely enough linked to economic activity in the short run to warrant inclusion as an endogenous variable in a guarterly model.

Identity (2) implies that we should calculate the total private stock as an identity after estimating rehabilitations, demolitions, and new private construction. Because we do not have data for demolitions and because we wanted initially to estimate as few equations as possible, we have instead used the identity in (3). Thus we estimate the total private stock and new private construction only. The total private stock is determined by the factors that determine its components (4). The equilibrium price and quantity result from the interaction of supply and demand (5) and (6). (Note that at this stage we are not explicitly dealing with disequilibrium adjustment processes, whose existence certainly must be recognized.) Similarly, supply and demand determine equilibrium price and quantity of new housing construction (7) and (8).

(1) Total Stock of Housing ≡ Total Private Stock + Total Publicly Assisted Stock
Total Publicly Assisted Stock is Exogenous

(2) Total Private Stock ≡ Total Private Stock (−1) + New Private Construction + Rehabilitations − Demolitions or

(3) (Rehabilitations − Demolitions) ≡ Total Private Stock − Total Private Stock (−1) − New Private Construction
Total Private Stock (−1) is Predetermined

(4) Total Private Stock = f_1(Total Private Stock (−1), New Private Construction, Rehabilitations, and Demolitions)

(5) Total Private Stock Demand = f_2 (Stock Price, New Price, Income, Publicly Assisted Construction, Mortgage Interest Rates)

(6) Total Private Stock Supply = f_3 (Stock Price, Mortgage Interest Rates, Cost of Rehabilitation, Total Private Stock(−1))

(7) New Private Construction Demand = f_4 (New Price, Price of Substitutes, Alternative Rates of Return, Household Operating Expenses, Mortgage Interest Rates, Income, New Publicly Assisted Construction)

(8) New Private Construction Supply = f_5 (New Price, Cost of Construction, New Publicly Assisted Construction, Rehabilitations, Mortgage Interest Rates)

(9) Total Private Stock Demanded ≡ Total Private Stock Supplied

(10) New Private Construction Demanded ≡ New Private Construction Supplied

Equations (5)-(8) are the structural equations describing the major relationships in the model's housing market. For estimation purposes, however, we have chosen to derive reduced form price and quantity equations for both the total private stock and new private construction utilizing the equilibrium conditions (9) and (10). By doing this we are able to easily examine the effects of exogenous and policy changes on prices and quantities. Furthermore, our simulation procedure requres that each endogenous variable appear in one equation as the dependent variable which results directly from the reduced from estimation. The reduced forms are in the following section where a price equation and a quantity equation for each sector have been estimated.

Note that the average price of the existing stock is assumed to be the same as the average price of units of the existing stock resold within any period. This implies that the distribution of sales is representative in its composition of the stock.

A disadvantage of estimating reduced form equations is that separate supply and demand equations are not obtainable (except when the system is exactly identified). All of the exogenous variables may appear in each reduced form equation and the expected signs may be ambiguous due to combining effects from both the supply and demand equations.

The accounting for the mortgage market and the specification of equations for it parallels that of the housing market so closely that a system of equations such as (1)∼(10) for the mortgage market would be redundant. Instead the estimated equations will be discussed in the next section.

Estimating and Simulating the Model

Each equation appears below with a brief explanantion of the variables and an indication of the theoretically expected signs (if any). The actual estimates appear below along with additional regression statistics. All estimates are ordinary least squares. Experimentation with two stage least squares indicated that very similar results would be obtained without any evident improvement in the model.

(11) NAEPHR, Average Existing House Price= ? C, Constant

+NPERMY, Real, per capita permanent income should have a positive effect on demand and price.

? NEMINT, The mortgage rate for existing housing should increase costs shifting the supply curve up along with price at the same time that it shifts the demand curve back. The dominant effect on price cannot be determined *a priori.*

−NHREPL, The number of units renovated should reduce demand and thus the price as is usually t for substitutes.

−NPHCTN, The volume of public construction also has the effect of a substitute on demand.

−NHEXPC, Expenses other than rent and mortgage payments will also shift demand back reducing the price.

+NRHCCT, The cost of rehabilitating units should reduce rehabilitation and thus increase demand for the existing stock.

Independent Variable	Estimated Coefficient	T-Statistic
C	−35255.9	−0.875659
NPERMY	19744.1	2.56209
NEMINT	1335.80	0.696331
NHREPL	−38.3689	−2.21692
NPHCTN	−2.76669	−0.547813
NRHCCT	49.1991	0.928392
NHEXPC	−40.9721	−0.509886

R-Squared=0.8228 Adj. R-Squared=0.7468
F-Statistic(6, 14)=10.8311
Durbin-Watson Statistic (Adj. for 0 Gaps)=2.5718

(12) NETHPQ, Existing Housing Quantity per Capita= ? C, Constant

+NPERMY, Income increases demand.

−NEMINT, Interest rates reduce demand and raise supply curves.

−NHREAL, Increasing the number of renovated units available reduces the demand for the existing stock.

−NPHCTN, Publicly assisted construction is also a substitute for the existing stock.

+NRHCCT, The cost of rehabilitating units acts like the price of a substitute goods on demand.

−NXEXPC, Housing related expenditures reduce demand.

+NETHQQ(−1), The size of the existing stock this period is highly dependent upon its size last period.

Independfnt Variable	Estimated Coefficient	T-Statistic
C	.991181E-01	9.57106
NPERMY	.707142E-02	3.71185
NEMINT	−.694151E-03	−1.78858
NHREPL	−.307652E-05	−1.09948
NPHCTN	−.358456E-05	−3.79269
NRHCCT	.346240E-07	0.480457
NREXPC	−.266366E-04	−2.05587
NETHQQ	.165583E-05	15.4608

R-Squared=0.9955 Adj. R-Squared=0.9929
F-Statistic (7, 12)=378.798
Durbin-Watson Statistic (Adj. for 0 Gaps)=2.2477

(13) NNTHQP, New Housing Units per Capita= ? C, Constant

+NPERMY, Income has a positive effect on demand and thus on quantity.

−NNMINT, Interest rates have a negative effect on demand and a negative effect on supply.

−NHREPL, Renovated units are a substitute for new housing and increasing their supply will reduce demand for new housing.

? NPHCTN, Publicly assisted units are also substitutes for new housing but public assistance may free private funds lowering costs and supply.

−NHEXPC, Housing expenditures other than the rent or mortgage payments are complementary goods in demand whose prices are negatively related to housing quantities.

−NNHCCT, Construction costs shift the supply curve upward reducing the equilibrium quantity.

Indedendent Variable	Estimated Coefficient	T-Statistic
C	.129976E-01	1.63361
NPERMY	.105906E-02	0.644143
NNMINT	−.129884E-02	−2.81242
NHREPL	−.169263E-05	−0.560069
NPHCTN	.518932E-06	0.445052
NHEXPC	−.109587E-04	−0.664160
NNHCCT	−.205521E-03	−2.84324

R-Squared=0.7918 Adj. R-Squared=0.7026
F-Statistic (6, 14)=8.87476
Durbin-Watson Statistic (Adj. for 0 Gaps)=1.7587

(14) NANHPR, Average Price of New Housing =? C, Constant

+NPERMY, Income has a positive effect on demand and thus on price.

? NNMINT, Interest rates have a negative effect on both demand and supply and the combined effect on price depends upon the relative shifts and the relative elasticities. The relatively greater elasticity of demand leads to the observed negative sign in this case.

? NHREPL, Again the impact of a substitute good on demand is negative.

? NPHCTN, Publicly assisted construction reduces demand but may also increase costs by competing for resources.

−NHEXPC, Housing expenses reduce demand, but are also correlated in their movements with cost increasing items.

+NNHCCT, Construction costs raise the supply curve.

−NETHQQ(−1), The size of the housing stock in the preceding period should reduce demand in the current period. The estimated coefficient is probably positive because the continually expanding stock is accounting for some of the income related price increases that are not accounted for in the real permanent income measure.

Independent Variable	Estimated Coefficient	T-Statistic
C	−136235.	−2.38030
NPERMY	1448.00	0.119430
NNMINT	−5518.79	−2.13759
NHREPL	−38.2011	−2.53129
NPHCTN	6.63126	1.13522
NHEXPC	−148.573	−2.06553

NNHCCT	430.347	1.26267
NETHQQ	1.82385	2.78924

R-Squared=.9144 Adj. R-Squared=0.8645
F-Statistic (7, 12)=18.3160
Durbin-Watson Statistic (Adj. for 0 Gaps)=2.0347

The mortgage market equations appear below. Most of the signs of the coefficients are as expected. Note that the equations, except for the number of mortgages extended for resale of existing houses, are estimated in log form.

(15) NEHMQQ, Value of Mortgages for Resale of Existing Houses=

Independent Variable	Estimated Coefficient	T-Statistic
C	−38936.3	−1.02415
NAEHPR	0.709085	2.16886
NPERMY	11602.9	1.39567
CORBND	−1237.63	−0.757425
MGTHLD	−.635923E-01	−1.40266
NETNSV	0.503650	2.58049

R-Squared=0.6371 Adj. R-Squared=0.5075
F-Statistic (5, 14)=4.91606
Durbin-Watson Statistic (Adj. for 0 Gaps)=1.6452

(16) LNEMINT, Log of Rate of Interest on Mortgages for Existing Houses=

Independent Variable	Estimated Coefficient	T-Statistic
C	−0.577256	−1.49895
LNAEHP	−0.137730	−1.38739
LNPERY	−0.842203	−3.47884
LCORFD	0.703447	6.20678
LMGTHD	0.313528	4.02351
LNETSV	−.329065E-02	−1.89199

R-Squared=0.9466 Adj. R-Squared=0.9275
F-Statistic(5, 14)=49.6468
Durbin-Watson Statistic (Adj. for 0 Gaps)=1.7721

(17) LNNHMQQ, Log of New Housing Mortgage Volume=

Independent Variable	Estimated Coefficient	T-Statistic
C	−21.8369	−2.10538
LNANHP	2.06130	0.895879
LNPERY	3.04491	0.459253
LCORBD	−3.74749	−1.21035
LMGTHD	0.856744	0.470881
LNETSV	.468141E-01	0.881314

R-Squared=0.6299 Adj. R-Squared=0.4978
F-Statistic (5, 14)=4.76640
Durbin-Watson Statistic (Adj. for 0 Gaps)=1.2482

(18) LNNMINT, Log of New Housing Mortgage Interest Rate=

Independent Variable	Estimated Coefficient	T-Statistic
C	−0.354547	−0.969419
LNANHP	−0.103984	−1.28165
LNPERY	−0.699059	−2.99011
LCORBD	0.525586	4.81403
LMGTHD	0.280151	4.36666
LNETSV	−.324097E-02	−1.73031

R-Squared=0.9277 Adj. R-Squared=0.9018
F-Statistic (5, 14)=35.9084
Durbin-Watson Statistic (Adj. for 0 Gaps)=1.4194

The volume of total new mortgages is a simple sum:

(19) NTHMQQ ≡ NNHMQQ+NEHMQQ

The average price of housing is a weighted sum:

(20) NAPROH ≡ ((NANHPR×NNTHQQ)+NAEHPR×NETHQQ))/(NNTHQQ +NETHQQ)

The number of rehabilitations and demolitions is found using (3):

(21) NRSDEM ≡ NETHQQ−NETHQQ(−1)−NNTHQQ

The individual equations reported above generally have R^2 values that indicate a significant amount of variation is explained by the independent variables. The values for the housing market have a higher range, .70 to .99, than do those for the mortgage market which range from .51 to .93. The Durbin-Watson statistics for all of the equations, while

not permitting a clean-cut conclusion of no autocorrelation, at least do not lie within ranges identifying positive or negative autocorrelation. The mean absolute percent errors for the estimated individual equations are shown below. Note that the performance of the price equations is much better than that of the quantity equations.

The individual equations were solved simultaneously using a simulation algorithm. The solution values for historical periods were compared with the actual values yielding the mean absolute percent error statistics shown below. Note the substantially unchanged MAPE's in the simultaneous solution.

The simultaneous model was also used to simulate the effect of exogenous changes on the regional housing and mortgage markets by increasing the values of several sets of exogenous variables by 5%. The results are shown below.

The model described above is almost totally dependent on regional variables; only the corporate bond rate is determined in a national market. This cannot be interpreted as showing that the regional housing and mortgage markets are independent from the national economy. The model at present is not capable of use in forecasting because many of its exogenous variables would first have to be forecast. We have built the above model to provide insight into the simultaneous nature of the regional market. As we move toward development of a forecasting model, more and more of the exogenous variables will be magnitudes for which forecasts can be obtained (such as U.S. interest rates or Delaware Personal Income).

Mean Absolute Percent Errors (MAPEs) for Equations Solved Independently

NAEHPR	2.81676
NNTHQP	35.02056
NAEHPR	4.00254
NETHQP	0.08478
NNMINT	1.14146
NNHMQQ	33.81626
NEMINT	1.23482
NEHMQQ	−20.12212

MAPEs for Equations Solved Simultaneously by Simulation

NANHPR	3.89507
NNTHQP	35.71763
NAEHPR	3.73477
NETHQP	0.12561

NNMINT	1.29170
NNHMQQ	32.49868
NEMINT	1.30792
NEHMQQ	20.84950

Variable Definitions and Data Sources

Endogenous Variables

1. NANHPR: Average New Housing Price ($). This is measured by the purchase price of newly-built houses (which use conventional mortgage loans) in the Philadelphia-Wilmington-Trenton Standard Consolidated Statistical Area (source: Statistical Division, Office of Economic Research, Federal Home Loan Bank Board).
2. NNTHQQ: New Castle County New Total Housing Quantity (# of units per capita). This is the number of permits issued for single and multi-family housing units encept for publicly insured and/or subsidized housing units (source: Division of Housing, Department of Community Affairs and Economic Development, State of Delaware).
3. NAEHPR: Average Existing Housing Price ($). This is the resale price of conventional mortgage-financed existing homes in the Philadelphia-Wilmington-Trenton SCSA (source: Statistical Division, Office of Economic Research, Federal Home Loan Bank Board).
4. NETHQQ: New Castle County Total Housing Quantity (# of units per capita). The existing housing stock is measured by adding net demolitions and new constructions in New Castle County since the 1970 census (source: 1970 Census of Housing, and Division of Housing, State of Delaware).
5. NNMINT: New Mortgage Interest Rate (%) which is measured by the effective interest rate on mortgages of newly-built homes in the Philadelphia-Wilmington-Trenton SCSA (source: Statistical Division, Federal Home Loan Bank Board).
6. NNHMQQ: New Housing Mortgage Quantity (000$). This is the total value of mortgage loans made for new homes in the Wilmington SMSA. Annual data from 1973.1 to 1976.4 are converted to a quarterly series by replicating the equivalent nations quarterly trends. The first quarter of 1977 through 1978 first quarter data, however, are sums of monthly totals (source:

Federal Home Loan Bank Board).

7. NEMINT: Existing Mortgage Interest Rate (%) which is measured by an effective mortgage interest rate on mortgages for the purchase of previously occupicd homes in the Philadelphia-Wilmington-Trenton SCSA (source: Federal Home Loan Bank Board).

8. NEHMQQ: Existing Housing Mortgage Quantity (000$). This is total mortgage loans made for existing home purchase in the Wilmington SMSA(source: Savings and Home Financing Source Book, Federal Home Loan Bank Board).

9. NTHMQQ: Total Housing Mortgage Quantity(000$). This is the total amount of mortgage loans made for new homes and existing homes in the Wilminton SAMS(source: Transformation).

10. NAPROH: Average Price of Housing which is the weighted average of the price of new and existing housing units (source: Transformation).

11. NRSDEM: Rehabilitations and Demolitions. This is a measure of rehabilitated housing units over demolished units (source: Transformation).

Exogenous Variables

1. NPERMY: New Castle County Real Per Capita Permanent Income (000$ per capita). Quarterly New Castle County figures are calculated from annual data using the quarterly pattern of State of Delaware personal income. These figures are then deflated using the Consumer Price Index and divided by estimated population to yield NRPERY, New Castle County Real Per Capita Personal Income. Permanent Income is then found using the formula:

$$\text{NPERMY} \equiv (1-e^{-b}) \sum_{j=0}^{S} (e^{-bj})\ \text{NRPERY}_{(t-j)}.$$

The weighting factors are chosen so that the sum of the weights will equal to 1 and the effect of a smaller weight coefficient ($b=0.2$) is to give relatively smaller weight to current income of the immediate past and relatively more to those of the more distant past (source: Bureau of Economic Analysis, U.S. Department of Commerce).

2. NHREPL: New Castle Housing Rehabilitation (# of units). This is the number of rehabilitated housing units in New Castle County (source: Division of

Housing, State of Delaware).

3. NPHCTN: New Castle Publicly Supported Housing Construction (# of units) which is measured by the number of housing units started with funding from public agencies like the Federal Housing Administration, the Farmers Home Administration, the Federal Department of Housing and Urban Development, and the Veterans Administration (source: Division of Housing, State of Delaware).

4. NHEXPC: New Castle Household Expenses ($). This expense includes real estate taxes, hazard insurance, and heating and utilities estimated by the FHA. The heating and utilities include the cost of heating, electricity, gas, water and other items generally known as utilities excluding sewage disposal, removal of garbage, etc. (source: Management Information System, College of Urban Affairs and Public Policy, Department of Housing and Urban Development).

5. NNHCCT: New Castle County New Housing Construction Cost (000$ per unit). This average construction cost is the value stated on the application for a building permit purpose. It excludes land, architectural and engineering costs (source: Division of Housing, State of Delaware).

6. NRHCCT: New Castle County Rehabilitation Housing Cost ($ per unit). This is the average cost of rehabilitating housing in New Castle County (source: Division of Housing, State of Delaware).

7. CORBND: Corporate Bonds Rate ($) which is measured by Moody's AAA corporate bond rate (source: Economic Indicators).

8. MGTHLD: Total Mortgages Held (000$) which combines conventional mortgage loans and VA guaranteed and FHA-HUD mortgage loans (source: Combined Financial Statements, Federal Home Loan Bank Board).

9. NETNSV: Net New Savings (000$). This is the difference between total savings received and withdrawals in the Wilmington SMSA (source: Federal Home Loan Bank Board).

10. NCSPOP: New Castle County Population (source: Current Population Reports, U.S. Department of Commerce, and Statistical Abstracts of Delaware).

Policy Analysis, Increase in Corporate Bond Rate 10%

Backcast on Variable Number 5 NNMINT

Date	Control SOLN	Policy SOLN	Difference	PCT Diff
1973. 2	7.47782	7.47782	0.00000	0.00
3	7.77738	7.77738	0.00000	0.00
4	8.08517	8.08517	0.00000	0.00
1974. 1	8.22370	8.22370	0.00000	0.00
2	8.44674	8.44674	0.00000	0.00
3	8.86758	8.86758	0.00000	0.00
	9.21868	9.21868	0.00000	0.00
1975. 1	8.80001	8.80001	0.00000	0.00
2	8.96544	9.49153	0.52609	5.87
3	8.96842	9.49647	0.52805	5.89
4	8.98704	9.52254	0.53550	5.96
1976. 1	8.91336	9.44873	0.53537	6.01
2	8.63534	9.14475	0.50942	5.90
3	8.69582	9.21050	0.51468	5.92
4	8.63931	9.15497	0.51566	5.97
1977. 1	8.71757	9.23581	0.51824	5.94
2	8.67459	9.19395	0.51936	5.99
3	8.61733	9.13077	0.51344	5.96
4	8.65216	9.16611	0.51394	5.94
1978. 1	8.80101	9.32129	0.52028	5.91

Policy Analysis, Increase in Population 1%

Backcast on Variable Number 1 NANHPR

Date	Control SOLN	Policy SOLN	Diefference	PCT Diff
1973. 2	39244.37586	39244.37586	0.00000	0.00
3	38800.72623	38800.72623	0.00000	0.00
4	37729.53625	37729.53625	0.00000	0.00
1974. 1	40519.45193	40519.45193	0.00000	0.00
2	42604.30229	42604.30229	0.00000	0.00
3	41920.58098	41920.58098	0.00000	0.00
4	42180.63443	42180.63443	0.00000	0.00
1975. 1	48112.18880	48112.18880	0.00000	0.00
2	45036.79268	47800.23878	2763.44610	6.14

3	48854.42659	53419.84586	4565.41927	9.34
4	48315.10468	54117.88369	5802.77901	12.01
1976. 1	47602.98046	54242.72404	6639.74358	13.95
2	53239.47675	60343.42668	7103.94992	13.34
3	53137.88126	60623.44282	7490.56156	14.10
4	50609.70814	58393.91691	7784.20877	15.38
1977. 1	52507.86695	60462.21967	7954.35272	15.15
2	50308.07636	58423.55912	8115.48276	16.13
3	51691.69189	59889.70104	8198.00916	15.86
4	52935.62931	61213.76486	8278.13555	15.64
1978. 1	55364.77592	63705.14891	8340.37299	15.06

Policy Analysis, Increase in Construction Cost 5%

Backcast on Variable Number 6 NNHMQQ

Date	Control SOLN	Policy SOLN	Difference	PCT Diff
1973. 2	1516.84881	1516.84881	0.00000	0.00
3	1226.95996	1226.95996	0.00000	0.00
4	798.02720	798.02720	0.00000	0.00
1974. 1	1058.63807	1058.63807	0.00000	0.00
2	985.19351	985.19351	0.00000	0.00
3	630.88295	630.88295	0.00000	0.00
4	484.21928	484.21928	0.00000	0.00
1975. 1	1039.65332	1039.65332	0.00000	0.00
2	936.05788	949.58090	13.52302	1.44
3	1116.01816	1134.60219	18.58403	1.67
4	1168.69082	1180.52094	11.83012	1.01
1676. 1	1303.93526	1322.14809	18.21283	1.40
2	1895.91560	1921.34502	25.42942	1.34
3	1835.72508	1858.78869	23.06361	1.26
4	2126.09159	2156.93736	30.84577	1.45
1977. 1	2375.81364	2405.66924	29.85559	1.26
2	2453.24817	2483.62568	30.37751	1.24
3	2822.19721	2855.57009	33.37288	1.18
4	2739.46106	2765.22205	25.76099	0.94
1978. 1	7927.58627	2963.65063	36.06436	1.23

Policy Analysis Increase in Construction cost 5%

Backcast on Variable Number 1 NANHPR

Date	Control SOLN	Policy SOLN	Difference	PCT Diff
1973. 2	39244.37586	39244.37586	0.00000	0.00
3	38800.72623	38800.72623	0.00000	0.00
4	37729.53625	37729.53625	0.00000	0.00
1974. 1	40519.45193	40519.45193	0.00000	0.00
2	42604.30229	42604.30229	0.00000	0.00
3	41920.58098	41920.58098	0.00000	0.00
4	42180.63443	42180.63443	0.00000	0.00
1975. 1	48112.18880	48112.18880	0.00000	0.00
2	45036.79268	45351.27115	314.47847	0.70
3	48854.42659	49247.41618	392.98959	0.80
4	48315.10468	48551.75319	236.64851	0.49
1976. 1	47602.98046	47924.39159	321.41113	0.68
2	53239.47675	53584.71422	345.23747	0.65
3	53132.88126	53455.68886	322.80760	0.61
4	50609.70814	50964.59752	354.88937	0.70
1977. 1	52507.86695	52826.94586	319.07892	0.61
2	50308.07636	50609.32782	301.25146	0.60
3	51691.69189	51987.33627	295.64438	0.57
4	52935.62931	53176.54034	240.91103	0.46
1978. 1	55364.77592	55694.60578	329.82985	0.60

Appendix A

Housing Demand By The Individual Consumer

The demand side of the housing market can be understood by examining the sequence of events constituting a consumer's housing search behavior.

The individual housing consumer makes a decision, in the first place, as to whether he will demand additional housing under his budget constraint by considering its possible returns and the costs involved. Since housing functions both as a consumption goods and as an investment goods, he considers not only the costs incurred in buying or constructing a house, but also the returns it may give as an investment. The attractiveness of housing as an investment is subject to the current price of housing and the return on a wide variety of alternative investments.

Once the individual consumer has determined to demand additional housing through either mortgage loans, his own capital, or income, the household next searches for the place for his residence among the alternative locations. The factors that appear to play a significant role in the locational decision are the distance from work place (or CBD), the socio-economic charactertics of neighborhood, and the availability of amenities in the neighborhood. The most influential socio-economic characteristics affecting the locational decision, in addition to the neighborhood school system, are the income level and ethnicity of neighborhood. The residential location decision is similar to industrial location behavior in the sense that the household probably looks first for the general region were the neighborhood and other characteristics are acceptable to it.

Having determined a general location for the residence, the household then turns its attention to selecting the specific site of housing (in the case of iudustrial location, this behavior is equivalent to the selection of a plant site). The selection considers physical features and major natural resource characteristics of the site in relation to housing.(1) The household may, in addition, consider the mitigation of possible pollution (including noise) and the utilization of solar energy potential in their decisions on the site selection.

In the final decison stage, the household chooses detailed housing characteristics such as

(1) The site's visual characteristics include ridge tops and valley bottoms, brooks and streams, views and vistas, significant vegetation and other aesthetic assets. On the other hand, the site's major natural resource characteristics are water supply, septic systems or sewers, buildings and dwellings, and roads and parking areas. For more information, see *The Developers' Handbook*, Department of Environmental Protection, The State of Connecticut, p. 45.

age, type and size. The selecion of housing characteristics is mainly affected by the size and the life cycle position of the family involved. (As a matter of fact, the life cycle of the family is related to all the stages of housing search behavior. This point is further elaborated in the next section).

The identification of the above stages of housing consumer behavior is intended to delimit the set of variables which differentiate the households which demand and those which do not demand housing. By using a binary response format for the first through the fourth stage (zero for a "no" response and one for a "yes" response), the four-stage behavior of the individual housing consumer can be integrated into a housing demand model, a proper location, site, and housing characteristics to reside in. The interrelation is flow-charted on the following page.

Aggregate Housing Demand

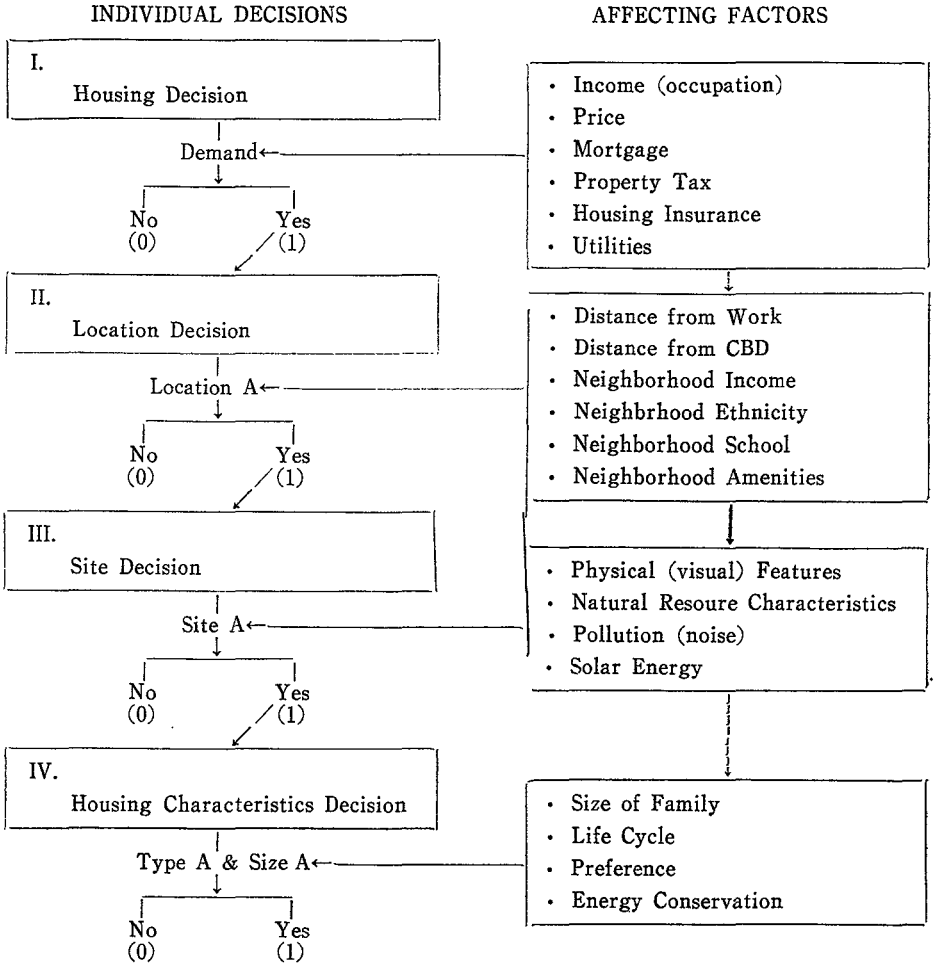
In principle, the aggregate (or market) demand for housing can be obtained by horizontally adding the housing demands of all of the relevant individuals which are articulated through the process of individual housing search behavior. By assuming each individual's locational decision within a spatially aggregated area to be given (instance, a city or county as a unit), aggregate housing demand can be simply explained by the factors affecting the first and last stages in the sequence of housing search behavior.

Any excess demand of desired housing stock over actual stock means an excess of current over equilibrium rent and, therefore, an incentive to add to the stock of housing. The housing stock may be adjusted either by increasing housing services(by, for instance, adding more rooms or renting space out) or by constructing new dwelling units. In neither case would the whole adjustment be expected to occur in one period. Thus, the expected pattern will be an expansion of occupancy rate of the existing inventory followed by new construction. Muth indicated that the rate of new conseruction in any year depends upon 1) the desired stock, expressed as a function of price, income, and the interest rate; and 2) the rate at which the actual housing stock moves toward it.[2] The reason for lags in housing markets relates to either the demand side or the supply side of the market for" new and existing housing[3]

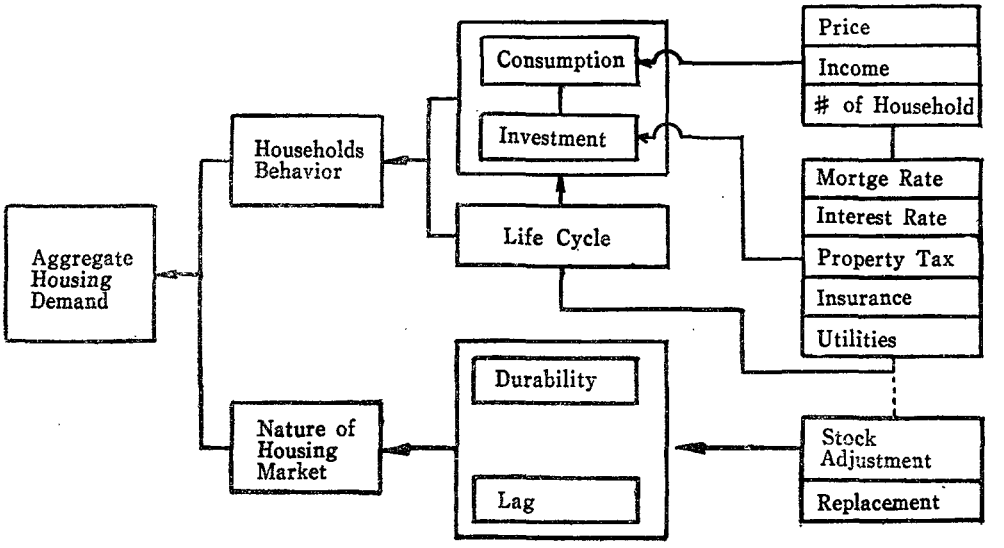
(2) Richard F. Muth, "The Demand for Non-farm Housing," in Alfred N. Page and Warren R. Seyfried, eds., *Urban Analysis: Readings in Housing and Urban Development* (Illinois: Scott, Foresman and Company, 1970), pp. 146-165.

(3) Maisel illustrated this lag phenomena using a figure which pictures a typical flow-feedback system. See Sherman J. Maisel, "A Theory of Fluctuations in Residential Construction Starts, in *Urban Analysis*, p. 125.

Fig I: Individual Housing Demand Behavior



Another exogenous factor affecting the aggregate demand and supply of housing is federally subsidized housing units. As the Kaiser Committee concluded, private enterprise alone cannot solve the nation's problems of housing the poor and therefore federal housing assistance remains essential for low-income families. In reality, decent housing has been a designated goal of national economic policy for all post-war administrations. Housing is probably the most heavily subsidized goods in the U.S. economy because of deductions for mortgage interest and property taxes of homeowners in their federal income returns (4). It seems noteworthy that as Edel and Rothenberg argue, public housing construction, through support of housing financing loans or other means, may affect the housing market for all groups positively, no matter what type of housing is supported, because of filtering



Note: This demand model lays more emphasis on the aggregate number of housing units rather than its type and/or size and, consequently, such factors as individuals' preferene and energy-consciousness are not explicitly considered here (this measurement problem will be raised again in the next section).

(2).

The market demand of housing in a spatially aggregate area, therefore, can be explained by both the factors affecting the first and last stages of housing searh behavior and the additional factors mainly relevant to the nature of housing market in its relation to the aggregate demand of housing. In other words, the housing demand of households in an urban area is characteracterized by the households' consumption and investment behavior under the constraints they face (one important constraint seems the situation in their life cycle) and by the nature of housing market with respect to its aggregate demand (the public-assisted housing construction as an exogenous factor in the housing market) is explicity dealt with in the model below.

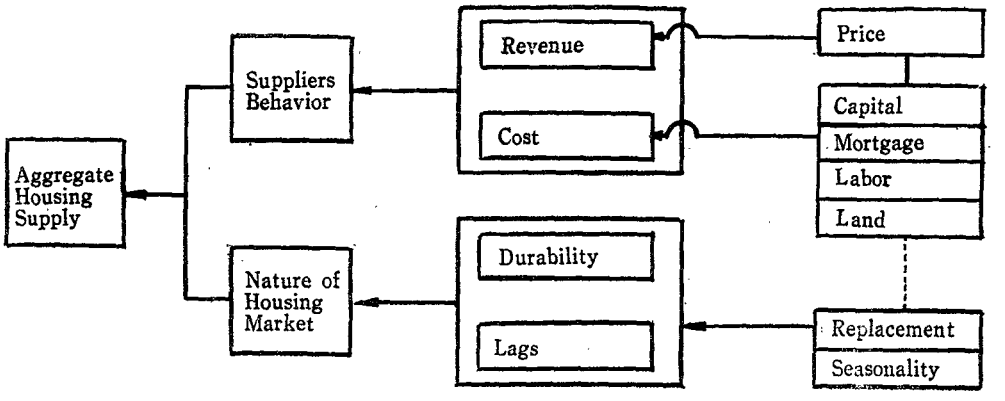
The Supply of Housing

Housing is supplied by individual households, developers, and public agencies. These suppliers can be builders of new housing and/or owners of the existing ones. The major supplier of housing, however, is developers whose whose motivations are mainly oriented toward profit-maximization. Analogous to the relationship between individual housing demand and its aggregate demand, the market supply of housing in a spatialliy aggregated area is the sum of the individual agents in that area per period of time. The quantity of housing supplied can be measured by the number of housing units made available to

households in an urban area.[4]

As mentioned above, housing supply can be characterized by suppliers' profit optimization behavior. Suppliers of housing presumably compare the present values of the costs and revenues resulted from producing housing units in the particular area.[5] Revenue is usually measured by the sale price of housing (multiplied by the number of housing units constructed or converted). The cost to supply a unit of housing is incurred by factors of production such as capital, labor and land (the main source of capital is generally the funds from the mortgage market). By considering both the discount rate and the time period relevant to housing investment in the calculation of present value, profit optimizers are able to determine the size and timing of housing supply (or investment).

The supply side of housing market also must have recognized the conversion of existing housing from lower quality (including vacant housing) to higher quality or from another land use to residential use. As de Leeuw and Struyk suggest, therefore, the supply side of housing model should consider the existing stock responds to economic incentives in its rate of depreciation or improvement (rehabilitation).[6] One of the main causes of lags in



(4) There is meredible variation among residential structures as to size, type of construction, floor space, and other characteristics to which households attach value. For this reason, some prefer to use housing value or the number of rooms (housing services) rather than using the dwelling unit as the unit of housing stock. See Richard F. Muth, "The Demand for Non-Farm Housing," in *Urban Analysis*, pp. 146-165.

(5) Bradbury, et al., indicate that suppliers of housing compare the present values of revenues and costs when deciding upon housing investment just as would an investor in any other enterprise. See Katharine Bradbury, Robert Engle, Owen Irvine, and Jerome Rothenberg, "Simultaneous Estimation of the Supply and Demand for Housing Location in a Multizoned Metropolitan Area," in Gregory K. Ingram, ed., *Residential Location and Urban Housing Markets* (Cambridge: Ballinger Publishing Company, 1977), pp. 51-86.

(6) Refer to Frank de Leeuw and Raymond J. Struyk, *The Web of Urban Housing* (Washington, D.C.: The Urban Institute, 1975).

housing supply is seasonal fluctuations in productions, although winter protection of housing construction has been demonstrated to be completely feasible.

The supply of housing units is also a function of the availability of mortgage credit during or after the construction is completed (home improvement loans are another factor which may have the potential to increase housing supply by, for instance, rehabilitating the existing vacant housing). Suppliers of housing seem more sensitive to financial conditions labeled as ease of borrowing, availability of mortgage funds, or supply of mortgage credit than demanders of housing, simply due to the magnitude of funds that they may need. As investors, housing suppliers who need mortgage lonans probably either porspone their investment decisions or switch their housing funds to other uses when the mortgage market compares unfavorably with alternative investment opportunities available to them.

The logic of the supply side of the housing market can be summarized in the following figure:(7)

Residential Mortgage Market

The mortgage market is one component of a complex system of financial intermediaries in which the flow of funds emanates from sectors of the economy with a surplus of funds at current prices to sectors with a net demand for funds. The mortgage market, therefore, is subject to changes by the factors affecting that system. The flow of funds is also likely to be altered by actions taken by Federal, state and local governments and by policies of the Federal Reserve System. This flow of funds is generated by individual firms, households and government in financial markets either through financial intermediaries or directly through households and businesses buying financial assets.

The residential mortgage market is specifically concerned with the supply and demand relationships of mortgage funds for residential construction or purchase of single-family housing, multi-family housing, and apartment complexes. Any analysis of this market, however, must also consider firms desiring to make investments in nonresidential developments.(8) The interaction between the demand for mortgage funds and the supply of available funds determines the mortgage interest rate and market terms on which funds are available. The terms and availability of mortgage credit have a direct bearing both upon

(7) As mentioned in the previous section, housing supply by public agencies is considered exogenous here.

(8) Residential mortgage loans, however, constitute the largest category of loans among the various types of mortgages made in the United States.

user demand for housing accommodations and builder and developer willingness and ability to undertake new construction.

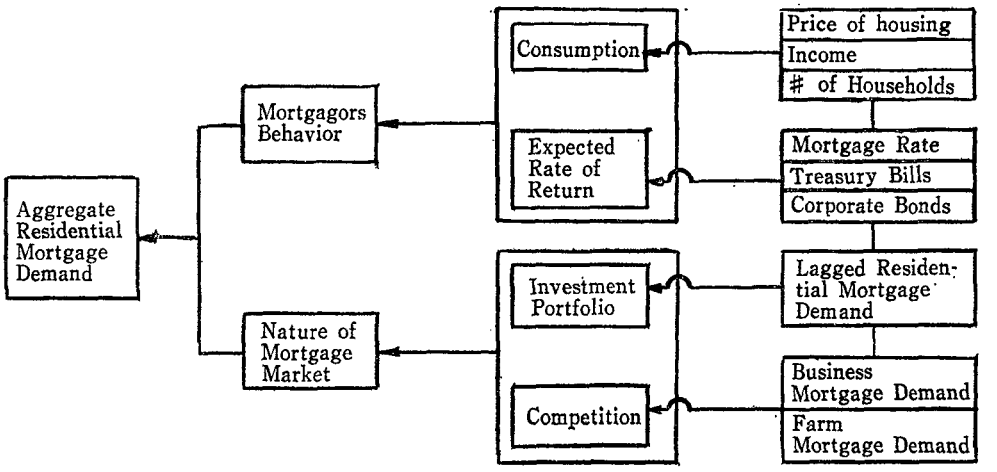
The demand for mortgage funds for the residential sector is primarily influenced by the same variables as those influencing the aggregate demand for housing:[9] 1) changes in the number of households; 2) changes in income (and employment); 3) the price of financing (and credit costs); 4) changes in current housing prices; and 5) changes in housing related expenditures.

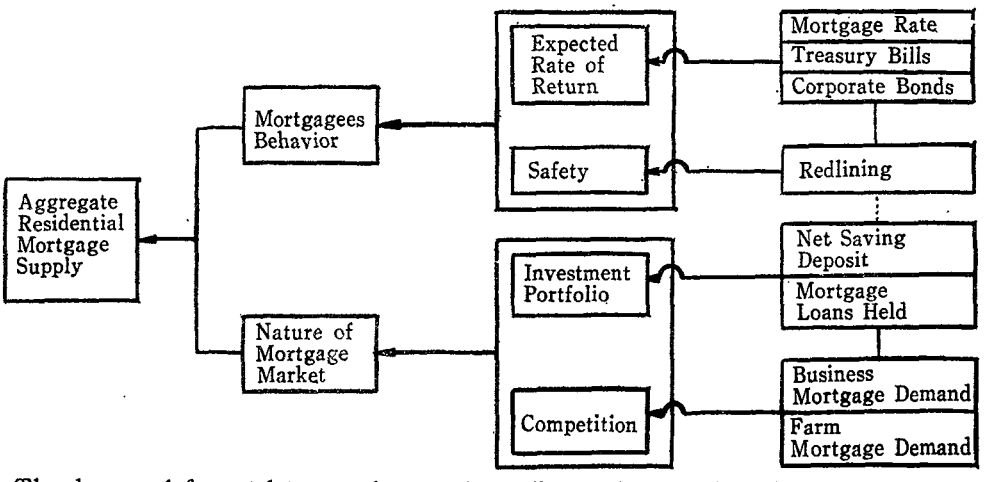
The supply of mortgage credit come both private financial institutions and federally-related agencies. The mortgage funds supplied by federally-related agencies have effects that are quite distinct from those of private lending agencies.[10] The aggregate supply of private mortgage funds is derived primarily from savings and associations, commercial banks, life insurance companies, and mutual savings banks, and is a function of 1) the yield on mortgages relative to the yield on alternative investment opportunities, 2) the size of an institution's net saving deposit (or investment portfolio), and 3) the size of its existing mortgage holdings, etc. (7). The supply of mortgage credit is especially affected by the opportunity cost of this credit which is the rate of return on alternative investments. The alternative rates on competing investments such as corporate bonds or obligations of federal, state and local governments have a negative influence on the supply for mortgage funds. Housing sector funds are also influenced by the level of general economic activity because the demand for mortgage funds is a part of the demand for all funds in the economy. When there is slack in the economy at large, the supply of funds is often ample relative to demand, and, consequently, credit for homebuilding and home purchase becomes more readily available. Alberts showed that a given percentage decrease in interest rates is associated with a large percentage increase in borrowing for construction, although he by no means established that the former completely explains the latter.[11]

(9) Refer to Lawrence B. Smith, "A Model of the Canadian Housing and Mortgage Markets," *Journal of Political Economy*, Volume 77, Number 5, September/October 1969, pp. 795-816, and also Henry E. Hoagland, Leo D. Stone, and William B. Brueggeman, *Real Estate Finance* (Illinois: Richard D. Irwin, Inc., 1977), Chapter 14.

(10) Federally-related agencies such as the Federal National Mortgage Association (FNMA), Federal Home Loan Mortgage Corporation (FHLMC), and various other agencies provide a secondary market for existing single-family and multi-family loans for lenders who seek an outlet for mortgages made during periods of rising interest rates, when funds for originating new loans become scarce. See Henry E. Hoagland, et al., *Real Estate Finance*, p. 382.

(11) See William W. Alberts, "Business Cycles, Residential Construction Cycles, and the Mortgage Market," in *Urban Analysis*, pp. 89-104.





The degree of financial intermediation also affects the supply of mortgage credit. If yields and interest rates rise on corporate bonds or U.S. Treasury bills relative to interest rates available on deposits offered by financial intermediaries, indivduals may choose to shift savings flows away from financial intermediaries and invest directly in securities (disintermediation). Consquently, in the short run there will be a reduction in total funds in dopositary-type institutions which are the primary participants in the mortgage market. For instance, when the Federal Government issued, in October 1977, three-year notes with an interest rate of 7.24 percent and a mid-November payment deadline, individual investor participation was about twice as high as previous note auction experiences.

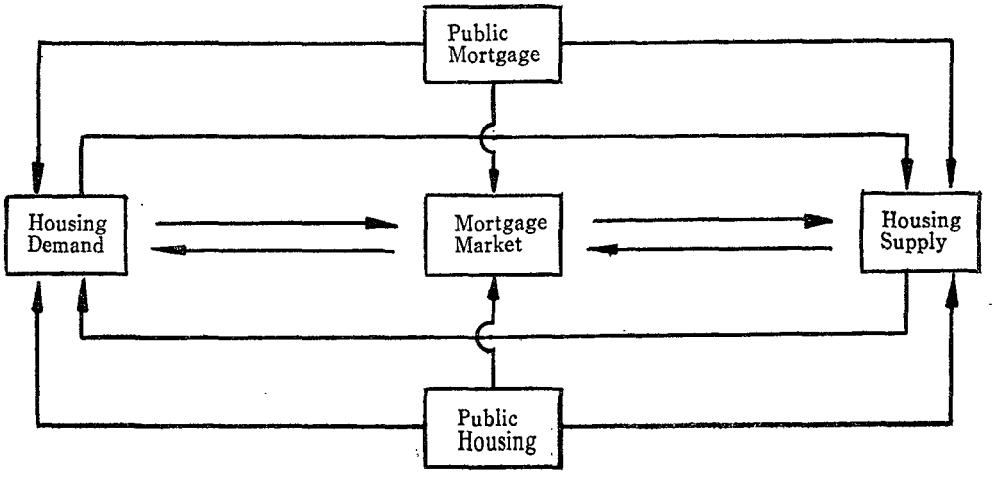
The above discussion on the mortgage market within a demand and supply contexs is

depicted in the following figures. As in the case of housing market, however, the consideration of federally-related agencies' impacts on the morgage market is suppressed.

Housing and Residential Mortgage Markets

The major components of the housing and residential mortgage markets thus far have been separately identified in their demand and supply framework. We now integrate both markets. Homebuyers or homebuilders borrow from many kinds of lenders under a wide variety of conditions. In all home loans (including home improvement loans), the borrower sells (and the lender buys) a set of future payments. Because of the risk involved the borrower may require that the loan payments yield him a return at least as great as the safe yield he could obtain on other assets plus a premium to compensate him for the risk of loss from delinquency or foreclosure. Participants in the residential housing market as shown above include demanding households, builders supplying new homes or altering existing structures, and financial intermediaries.

The Federal (or local) Government has become an additional participant in the residential housing and mortgage markets by playing a significant role as both producer and subsidizer of housing. Public concern about inadequate housing and deteriorating neighborhoods grew during the 1960s and found expression in the Housing and Urban Development Act of 1968, which pledged federal assistance in building or rehabilitating 26 million housing units in the following decade (9). The Federal Government also undertakes a number of programs designed to help homebuyers borrow on less stringent terms. The largest and most important are the programs of mortgage insurance administered by the Federal Housing Administration(FHA) and the system of loan guarantees administered



by the Veterans Administration (VA)[12]

The following figure indicates the forementioned simultaneous relationships within and between the residential housing and mortgage markets (mortgage market also, of course, has simultaneous relationship between its demand and supply). Federally-assisted housing (pubilc housing) and U.S. Treasury obligations (public mortgage) are considered here as exogenous factors to affect both residential housing and mortgage markets:

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(12) The government intervention in the residential housing and mortgage markets can be listed as follows: implicit tax subsidies to home owners; mortgage insurance and loan guarantees; low rent public housing; and other subsidies to low and middle income renters and home owners. See Henry J. Aaron, *Shelter and Subsidies: Who Benefits from Federal Housing Policies?* (Washington, D.C.: The Brookings Institution, 1972).

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