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Builders' Reactions to Changes in Demand : A Theory of Short Run Fluctuation in Residential Single Family Housing Starts

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BUILDERS' REACTIONS TO CHANGES IN DEMAND: A THEORY OF SHORT RUN FLUCTUATIONS IN RESIDENTIAL SINGLE FAMILY HOUSING STARTS

BY

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OF SHORT RUN FLUCTUATIONS IN RESIDENTIAL
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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor | Date

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Chapter 1

INTRODUCTION

One factor which distinguishes the production of non-mobile housing from the production of other consumer goods is the relatively long duration of the production process. A recent study found the median construction period for single family units to be three months, the mean length being 4.3 months.[1] The implication is that, for single family housing, the level of inventory under construction is approximately three to four times the level of monthly starts and completions.

The existence of a large, mostly unsold inventory in various states of completion is required if builders are to have a marketable supply of units available at all times. However, this inventory is a continuous financial burden, and financing costs reduce builders' profits. If the level of realized sales falls short of the level of sales expected by a builder, it will create undesired increases in the level of inventory, reducing profits and threatening the builder's existence in the industry. In order to reduce inventory to desired levels, the builder must either change his marketing policies in an effort to sell more units or reduce his starts of new units, or both.

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[1]Bernard N. Freedman, "Private Housing Completions -- A New Dimension in Construction Statistics," Staff Economic Studies of the Board of Governors of the Federal Reserve System, LXVI (February, 1972), 14-15.

In this paper the author is concerned only with fluctuations in starts of new single family housing units. The reason for excluding multi-unit construction from the analysis is the relative absence of speculative risk to the builder. New multi-unit structures are usually sold to an investor before construction is begun. The investor, rather than the builder, bears the risk of selling or renting the constructed units. In contrast, between 1963 and 1971 79 percent of all single family housing units were started without any commitment from buyers.[2] Until these units are sold, the costs and risks of carrying a large unsold inventory remain with the builder.

PURPOSE AND SCOPE

The author of this study developed for statistical analysis three models in an effort to explain fluctuations in residential single unit housing starts. Specifically, the proposition embodied in these models states that residential builders vary their starts of new single family housing units for two reasons. First, builders' expectations of future sales are constantly being revised according to their sales experience. Second, builders attempt to adjust their unsold inventory to desired levels, given their sales expectations.

Data recording sales and unsold inventories of new single family

[2]This data is in terms of "units of housing." See U.S. Department of Commerce, Bureau of the Census, C-25, Sales of New One-Family Homes (Washington: U.S. Government Printing Office, monthly). In this study, sales and inventory are discussed in unit terms unless otherwise stated.

housing units have been published monthly since 1963.[3] The data analyzed cover the period from January 1965 to December 1971. The data represent permit and nonpermit areas of all 50 states.

Since changes in "expectations" and in "desires" are not directly observable, one must resort to models in which changes in expectations or desires are a function of observable phenomena. One class of models which performs this function is referred to as "adaptive expectations" models.[4] The author proposes three alternative adaptive expectation models to explain how builders form sales expectations.

STUDY OVERVIEW

In the remainder of this chapter, the author reviews previous studies of the residential construction industry. In Chapter 2, the author introduces the framework of housing supply dynamics, develops the three models into a form amenable to statistical analysis, discusses the data used in the analysis, and discusses the estimation problems anticipated. In Chapter 3, the author presents and interprets the statistical analyses of the propositions embodied in the models. The summary and conclusions are presented in Chapter 4.

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[3]U.S. Department of Commerce, Bureau of the Census, C-25, Sales of New One-Family Homes (Washington: U.S. Government Printing Office, monthly).

[4]Jan Kmenta, Elements of Econometrics (New York: The Macmillan Company, 1971), pp. 473-474.

REVIEW AND CRITIQUE OF PREVIOUS STUDIES

It is proposed by the author that builders' expectations regarding the profitability of new housing starts are based upon three classes of economic information. The first class of information regards economic and demographic conditions, both in the aggregate and in local areas. Such information includes changes in population, the levels of income and employment, and the cost and availability of mortgage credit to potential buyers.[5] The second class of information is concerned with conditions in housing markets, specifically the level of housing prices and rents and the rate of utilization of the current housing stock. The third class of information regards builders' performance, where "performance" refers to the number of units that buyer-occupiers and investors are willing to absorb from existing inventories.

It is further proposed by this author that the first class of information is the weakest and may be incorporated into a single variable, i.e., sales, in analyzing fluctuations in builders' starts of new housing units.

The second class of information is reviewed below. The applicability of the third class of information is the subject of this thesis.

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[5]This author assumes that changes in these determinants will cause changes in sales, thereby changing sales expectations. For a discussion of the effects of these potential determinants, see Leo Grebler and Sherman J. Maisel, "Determinants of Residential Construction: A Review of Present Knowledge," A Series of Research Studies on the Impacts of Monetary Policy Prepared for the Commission on Money and Credit, No. 4 (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963), pp. 476-477.

Builders' Perceptions of Changes in Demand for Housing

At present two economic theories describe how changes in conditions in housing markets are transmitted to builders. The first theory hypothesizes that fluctuations in housing starts are caused by changes in the level of rents and prices on existing housing relative to changes in the cost of contructing new housing.[6]

The mechanics of the theory state that an exogenous change in demand, from whatever source, reduces the vacancy rate on existing dwellings. A decreasing vacancy rate tends to increase rents on existing dwellings. Viewing the housing stock as assets held by investors, rising rents increases the return to holders of housing assets relative to the return on alternative investments. In turn, the increasing return to an asset causes a revaluation of its price. For housing assets, increasing returns will increase the value of the existing housing stock, increasing the price per unit of that stock. Investors will desire to contract for more units as long as the acquisition price does not reduce the rate of return below that of alternative investments.

Confronted by rising prices for their product, builders are encouraged, by higher profit expectations, to increase the number of units started. Housing starts will increase until either overbuilding occurs or construction costs increase. Overbuilding causes an increase in the vacancy rate, tending to decrease the rate of change of rents. If the return to holders of housing assets decreases relative to the yield on

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[6]Ibid., p. 481.

alternative investments, housing assets are devalued and the price per unit of the housing stock falls.

If construction costs are increasing due to the higher rate of production in the residential construction industry, the combined effects of falling prices and rising costs will cause builders to reduce their starts of new units.[7]

Statistical models have embodied this theory in several fashions. Derksen constructed a model of housing starts using rents and construction costs as separate independent variables.[8] Most authors utilize a ratio of rent to construction costs as a single independent variable, with or without a time lag.[9] Smith constructed a model of Canadian housing starts using a ratio of housing prices to construction costs.[10]

Tests of these variables on annual data have been mostly successful. Regression coefficients of these variables have been significant and the direction of influence has been in accordance with hypothesized expectations.

However, there is reason to doubt the usefulness of these

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[7]By falling prices the author means that the rate of increase in prices falls below the rate of increase of construction costs. Decreasing prices are not a characteristic of the U.S. economy for the period under observation.

[8]J.B.D. Derksen, "Long Cycles in Residential Building," Econometrica, X (April, 1940), pp. 97-116.

[9]Sherman J. Maisel, "A Theory of Fluctuations in Residential Construction Starts," American Economic Review, LIII (June, 1963), pp. 359-383.

[10]Lawrence B. Smith, "A Model of Canadian Housing and Mortgage Markets," Journal of Political Economy, LXXVII (September-October, 1969), pp. 795-816.

variables in short run analysis. Whereas housing starts have fluctuated considerably on a monthly and quarterly basis, variations in rents and construction costs have not been substantial within the same time frame.

The efficiency of rents and prices as market signals to builders is subject to another criticism. Housing is probably the most heterogeneous of consumer goods, varying in size, age, location, and accomodations offered (such as garages, basements, and central air conditioning). Therefore, interpretations of changes in rents and prices must be made with caution. Changes in rents and prices may be due to changes in qualitative services offered or due to changes in demand or both.

A notable deficiency of most construction cost indices is the failure to include land costs. Therfore, existing measures of construction cost do not adequately reflect changes in cost to builders of providing a unit of housing.[11]

If changes in prices, rents, and construction costs are considered unreliable indicators of changes in housing market conditions, another source of market signals is available. When an increase in demand occurs in the market for any economic good, economic theory asserts that in the short-run the price of the good will increase and that the quantity traded will increase, if technology remains unchanged and factor prices are unchanged.

That an increase in demand will increase the quantity traded is

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[11]Construction cost indices employed by the U.S. Department of Commerce do not include land or builders' overhead expenses.

the second economic theory. In housing markets, this is exhibited in changing vacancy rates on existing housing units and increases in sales of new single family housing units to owner-occupiers. Maisel has included vacancy estimates as an independent variable in a regression model of housing starts. These estimates were derived as a residual by reference to a comprehensive model of housing markets.[12] Maisel's opinion was that the estimates are more illustrative than accurate even though the vacancy variable was statistically significant and had the a priori direction of influence.[13]

Adjustments of Housing Inventories

The theory that the level of housing inventories may cause variations in starts of new units was authored by Grebler and Maisel.[14] A description and statistical analysis of the fully developed theory was published by Maisel.[15]

In these studies, "inventory" included all units under construction and all completed units held vacant for sale or rent. An inventory of vacant units, while possibly desirable from the social viewpoint to accommodate migration and family formation, is undesirable from the point of view of the individuals who hold the inventory.

The major cause of fluctuations in inventories is described as overbuilding or underbuilding. If demand increases, due to changes in

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[12]Maisel, op. cit., pp. 382-383.

[13]Grebler and Maisel, op. cit., p. 567.

[14]Ibid., pp. 573-576.

[15]Maisel, op. cit., p. 366.

the number of households and removals of units from the existing housing stock, the level of inventory decreases. Recognition lags in market information will delay increases in building until inventories have decreased further. The building boom, once begun, will continue beyond the point of equilibrium and inventories will increase rapidly, again because of recognition lags.

The level of the inventory of housing units under construction is a function of builders' sales expectations and of the time required to produce a unit of housing. Grebler and Maisel believe that builders will attempt to maintain a "certain ratio of units under construction to sales," and that builders will increase this ratio when sales increase and decrease this ratio when sales decline.[16]

Grebler and Maisel warn against considering all fluctuations in housing starts to be reflections of changes in basic demand and supply forces.[17] By Maisel's estimates, fifteen percent of the variation in housing starts is caused by immediate changes in demand while 85 percent is attributable to changes in the level of inventories.[18]

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[16]Grebler and Maisel, op. cit., p. 575.

[17]Ibid., p. 607.

[18]Maisel, op. cit., p. 361.

Chapter 2

DERIVATION OF THE MODEL

THE FRAMEWORK OF THE CONSTRUCTION PROCESS FOR SINGLE FAMILY HOUSING UNITS

The flow-feedback network for a typical builder and for all builders as a group is outlined in Figure 1.

The construction process consists of blocks 1, 2, and 3. A housing unit is recorded as a start when a foundation is excavated or a footing is begun. Simultaneously, the units becomes a part of the builder's inventory under construction. The inventory under construction includes all started units in various stages of production until the finished flooring is installed. At that point, the unit is recorded as a completion. Completed units are then relinquished to buyers, if sold, or enter the builder's inventory of completed units.

As indicated in Figure 1, units are sold before the beginning of construction, during construction, and after completion. Builders' liabilities are reduced whenever a unit is sold and increased whenever an unsold unit is started. Although the builder has the obligation to complete all units which have been sold, his willingness and ability to start additional units is limited by the level of his unsold inventory.

Depending upon the level of sales and unsold inventory, the builder will form some expectation of future sales and inventory requirements. This will form the basis of the number of units he will start in the next period.

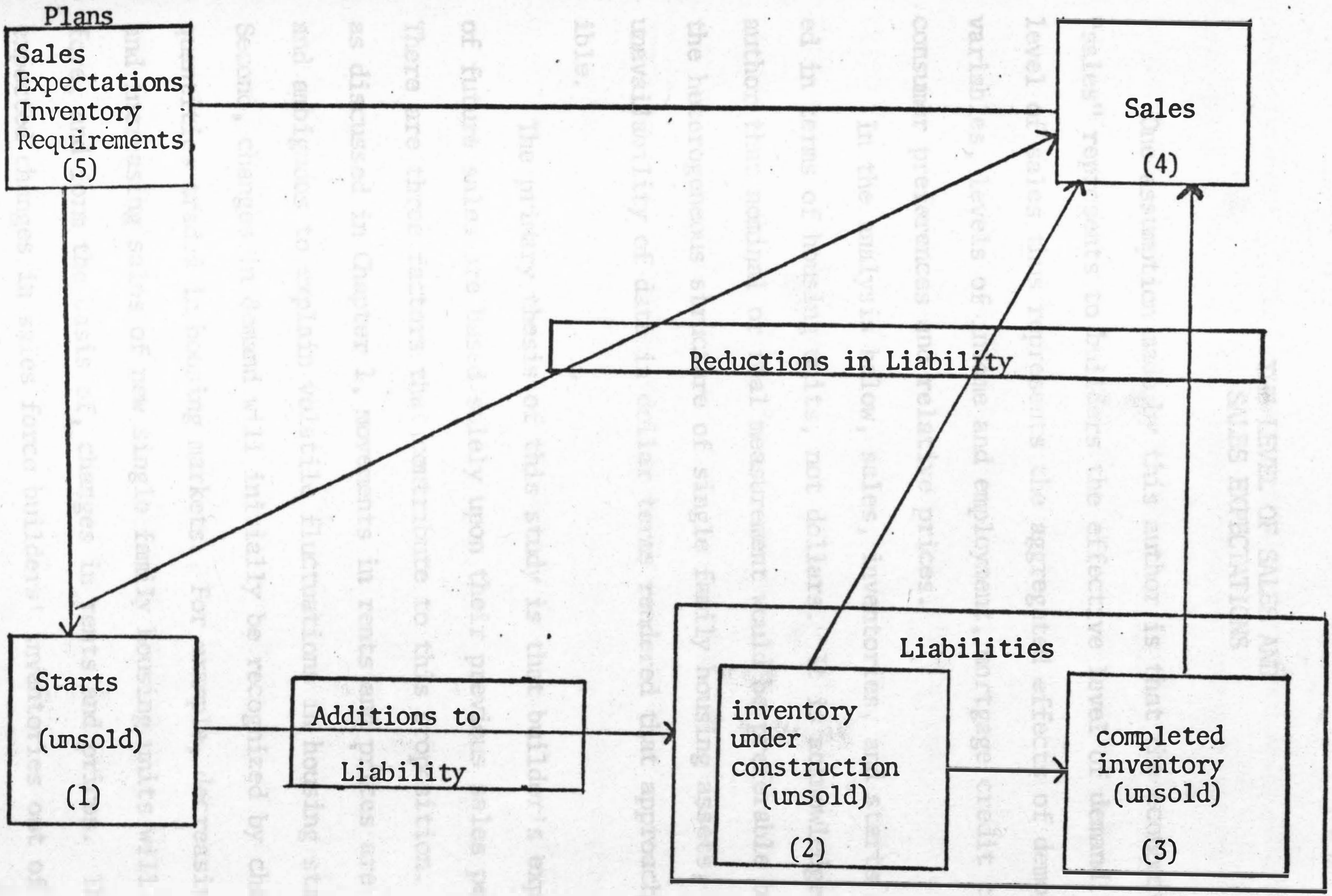

Figure 1

Product, Liability, and Information Flows in Construction Markets

THE LEVEL OF SALES AND SALES EXPECTATIONS

One assumption made by this author is that the economic variable "sales" represents to builders the effective level of demand. The level of sales thus represents the aggregated effects of demographic variables, levels of income and employment, mortgage credit conditions, consumer preferences and relative prices.

In the analysis below, sales, inventories, and starts are measured in terms of housing units, not dollars. It is acknowledged by this author that nominal or real measurement would be preferable because of the heterogeneous structure of single family housing assets, but the unavailability of data in dollar terms rendered that approach impossible.

The primary thesis of this study is that builder's expectations of future sales are based solely upon their previous sales performance. There are three factors that contribute to this proposition. First, as discussed in Chapter 1, movements in rents and prices are too slow and ambiguous to explain volatile fluctuations in housing starts. Second, changes in demand will initially be recognized by changes in quantities traded in housing markets. For example, decreasing vacancies and increasing sales of new single family housing units will occur before, and form the basis of, changes in rents and prices. Third, unexpected changes in sales force builders' inventories out of equilibrium. If inventories are reduced by unexpected increases in sales, the builder must replenish the unexpected depletion of his inventory if he is to take advantage of the high sales potential. When sales are decreasing more quickly than expected, inventories are increasing beyond levels required for future sales. Builders must avoid carrying inventories which are either beyond their abilities to obtain financing or which, due to financing costs, eliminate substantial profits.

If one accepts that builders form sales expectations from their previous sales performance, one must still allow that there are different methods by which this can be accomplished, each yielding a different estimate of future sales. Those methods, while forming a continuum, can be divided into two groups according to the types of predictions obtained. The first group of methods are those that yield "explosive" predictions. These methods are characterized by assigning large weights to current changes in sales, with future changes in sales expected to be greater than the current changes. An example from accelerator theory[1] would be:

$$\Delta S_t^e = \beta\,(S_{t-1} - S_{t-2}) \tag{1}$$

where ΔS_t^e represents the expected change in sales for period t, S_{t-1} and S_{t-2} represent actual sales in periods (t-1) and (t-2), and β is a constant accelerator coefficient. β, in this case, must be greater than one for the model to yield explosive predictions. This is seen

[1]Stanley Bober, The Economics of Cycles and Growth (New York: John Wiley & Sons, 1968), p. 189.

more clearly by expanding equation (1) to read:

$$S^e_t - S^e_{t-1} = \beta\,(S_{t-1} - S_{t-2}). \tag{2}$$

Since housing starts do not behave in an explosive manner, the possibility that builders' sales expectations are explosive must be rejected.

Several explosive business cycle theories are limited by "ceilings" and "floors." A quantitative expression of ceilings and floors might involve a variable accelerator coefficient instead of a constant. This coefficient would assume large values during upswings and downswings, but would assume values less than one at turning points. However, since the variable accelerator coefficient is a function of economic conditions other than housing sales, it violates the prior assumption that builders depend solely on sales experience for their expectations of future sales.

The second group of methods "smoothes out" abrupt changes in current activity to yield "damped" predictions. The smoothing process is obtained by weighting past observations more heavily, i.e., by applying declining weights to observations prior to period (t-2). Therefore current sales expectations are formulated by weighting values of sales. Dampening can also be achieved by restricting β to values less than one. The models of sales expectations used in this study restrict β to values less than one and are dependent upon past observations of sales.

MODELS OF SALES EXPECTATIONS

This author proposes that builders' sales expectations are formed by reference to their sales performance in previous periods. Though an explosive sales expectation mechanism is rejected, there remains a large variety of nonexplosive models which are justifiable on theoretical grounds. Three of these types of models are examined in this study.

The first model states that builders will expect sales at the conclusion of the present period (S_t^e) to be equal to the level of sales in the previous period (S_{t-1}) plus some constant proportion of the change in sales between the two previous periods ($S_{t-1} - S_{t-2}$), or

(3) $$S_t^e = \beta\ (S_{t-1} - S_{t-2}) + S_{t-1},\ 0<\beta<1.$$

The model implies that the change in expected sales between period (t) and period (t-1) will be in the same direction as the actual change in sales between periods (t-1) and (t-2). The dependence upon previous period activity implies that builders' recognition and reaction lag is one period.

The second model states that expected sales at the conclusion of the present period are equal to the expected sales of the previous period (S_{t-1}^e) plus a constant proportion of the difference between actual and expected sales for the previous period ($S_{t-1} - S_{t-1}^e$), or

(4) $$S_t^e = C\ (S_{t-1} - S_{t-1}^e) + S_{t-1}^e\ ,\ 0<C<1.$$

If actual sales exceeded expectations for the previous period, builders would increase their expectations of current period's sales.

Third model is similar to the second. Builders revise their sales expectations to equal the actual level of sales in the previous period (S_{t-1}) plus a constant proportion of the difference between actual and expected sales for the previous period ($S_{t-1} - S^e_{t-1}$), or

$$(5) \qquad S^e_t = D\,(S_{t-1} - S^e_{t-1}) + S_{t-1}\,, \; 0<D<1.$$

<u>Geometrically Distributed Lags</u>

The second and third models generate geometrically distributed lags on previous levels of sales because of the existence of S^e_{t-1} on the right side of equations (4) and (5).[2] In order to estimate these functions, either by themselves or within a larger model, all "expected" magnitudes (S^e) must be removed. This is accomplished below.

Since equation (4) is defined as

$$(4) \qquad S^e_t = (C)(S_{t-1} - S^e_{t-1}) + S^e_{t-1}$$

then

$$(4a) \qquad S^e_t = (1-C)\; S^e_t + (C)\; S_{t-1}$$

and

$$(4b) \qquad S^e_{t-1} = (C)(S_{t-2} - S^e_{t-2}) + S^e_{t-2} = (1-C)\; S^e_{t-2} + C\; S_{t-2}$$

Substituting equation (4b) into equation (4a) yields

$$(4c) \qquad S^e_t = (1-C)[(1-C)\; S^e_{t-2} + CS_{t-2}] + (C)\; S_{t-1}.$$

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[2]Equation (3) is a first-order difference equation and therefore does not involve a declining weights distributed lag sequence.

Rearranging equation (4c) yields the following series:

(4d) $$S_t^e = (C)\ S_{t-1} + (1-C)(C)\ S_{t-2} + (1-C)^2\ S_{t-2}^e.$$

Carrying the series to (t-n) periods, n approaching infinity, yields:

(4e) $$S_t^e = (C)\sum_{n=0}^{\infty} (1-C)^n\ S_{t-1-n}\ ,\ 0<C<1.$$

The coefficient $(1-C)^n$ for the individual sales values (S_{t-1-n}) causes the relative weights of the previous values of sales to decline as the time period becomes further removed from the present time period, such that the effect of distant values of sales eventually approach zero.

From equation (5), or

(5) $$S_t^e = D\ (S_{t-1} - S_{t-1}^e) + S_{t-1},$$

then

(5a) $$S_t^e = (1+D)\ S_{t-1} - (D)\ S_{t-1}^e$$

therefore

(5b) $$S_{t-1}^e = (1+D)\ S_{t-2} - (D)\ S_{t-2}^e$$

Substituting (5b) into equation (5a) yields

(5c) $$S_t^e = (1+D)\ S_{t-1} - D\ (1+D)\ S_{t-2} + D^2\ S_{t-2}^e$$

Carrying the series to (t-n) periods, where n approaches infinity, yields the following distributed lag:

(5d) $$S_t^e = (1+D)\sum_{n=0}^{\infty} D^{-n}\ S_{t-1-n},\ 0<D<1.$$

Again, $(D)^{-n}$ causes declining weights for distant values of sales. However, the values of the weights alternate in sign for this model, i. e., the level of S_{t-1} has a positive influence upon S_t^e, but the level of S_{t-2} has a negative influence, though of less magnitude.

Obviously an infinite number of lagged sales variables cannot be estimated. This problem will be considered later in this chapter.

A MODEL OF INVENTORY ADJUSTMENT

The need for a relatively large inventory under construction exists because of the length of the construction period. A completed inventory is generally required to accommodate expected sales for a given period. The upper limit of total inventory holdings depends upon builders' desire to avoid risk on speculative construction and upon their ability to obtain financing and to absorb the carrying costs associated with that financing.

The definition of inventory employed by this author is the sum of all started, but unsold, units held by builders, i.e., the unsold inventory under construction plus the unsold inventory of completed units.

The author proposes that the level of inventory builders desire to hold (I_t^*) is a function of their expected sales in the near future, where the functional relationship is determined by the length of the construction period. For example, if the construction period is exactly three months, builders would desire to hold an inventory equal to expected sales for the next three months, or

$$I_t^* = S_t^e + S_{t+1}^e + S_{t+2}^e.^3 \tag{6}$$

The assumption that builders cannot forecast sales levels accurately more than one period in advance alters equation (6) to

$$I_t^* = (A)S_t^e, \tag{7}$$

so that desired inventory is a function of the current period's expected sales. The author assumes that "A", the functional relation between desired inventory and expected sales, is a constant, or

$$A = I_t^*/S_t^e . \tag{8}$$

At the end of the previous period (t-1), builders hold a given level of inventory (I_{t-1}) which is the outcome of the previous period's levels of starts and actual sales. Builders will estimate the level of expected sales in the forthcoming or current period (t) according to the sales expectation models introduced earlier. Builders will then use their estimate of expected sales to calculate the level of desired inventory according to equation (7). If the level of desired inventory differs from builders' actual inventory ($I_t^* - I_{t-1}$), builders will attempt to reduce the gap in future periods by starting more units than they expect to sell in the immediate future, if I_t^* is greater than I_{t-1}, or by starting fewer units than they expect to sell, if I_t^* is less

[3]This holds only when expected sales and unsold inventory are in unit terms.

than I_{t-1}.

The assumption employed here is that builders will attempt to close the gap $(I_t^* - I_{t-1})$ by the end of the current period. That is, the model of inventory adjustment assumes complete adjustment. But for the complete inventory adjustment to be accomplished, actual sales must equal expected sales in the current period. If actual sales differ from expectations, the desired inventory adjustment will not be achieved if S_t excees S_t^e, but will be more than achieved if S_t is less than S_t^e.

If builders accomplish the desired inventory adjustment in period (t), the desired level of inventory for period (t+1) will differ from I_t^* if builders change their sales expectations for period (t+1).

THE COMPLETE MODEL

The complete model incorporates the models of sales expectations, the model of complete inventory adjustment, and the level of new housing starts (ST_t) in the following behavioral equation:

$$ST_t = S_t^e + (I_t^* - I_{t-1}). \tag{9}$$

The equation states that builders' starts are equal to the level of expected sales plus the difference between desired and actual inventories.

Equation 9 contains two terms not directly observable, S_t^e and I_t^*, which must be eliminated before the parameters can be specified.

The first substitution is for I_t^* according to equation (7), which results in

$$ST_t = (1+A)\,S_t^e - I_{t-1} + \alpha_t\,, \tag{10}$$

where α_t is a stochastic error term. The next step involves substituting for S_t^e according to each sales expectation model.

Model 1-Equation (3)

Substituting for S_t^e according to equation (3) results in

$$ST_t = (1+A)[(1+B)S_{t-1} - (B)S_{t-2}] - I_{t-1} + \alpha_t\,, \tag{11a}$$

which simplifies to

$$ST_t = (1+A)(1+B)S_{t-1} - (B)(1+A)S_{t-2} - I_{t-1} + \alpha_t\,. \tag{11b}$$

Equation (11b) is not yet ready for estimation because I_{t-1} has no regression coefficient. There are two methods to remedy this situation.

The first method is to add I_{t-1} to both sides of equation (11b) yielding

$$ST_t + I_{t-1} = (1+A)(1+B)S_{t-1} - (B)(1+A)S_{t-2} + \beta_t\,. \tag{11c}$$

The theoretical justification of equation (11c) is that ST_t plus I_{t-1} measures the willingness of builders to engage in speculative construction. By rearranging equation (10), one obtains

$$ST_t + I_{t-1} = (1+A)S_t^e + \alpha'_t\,. \tag{10a}$$

Builders' willingness to engage in speculative construction depends upon the level of their sales expectations. This result is similar to equation (10), which states that builders' willingness to add to their level of financial liability by starting more units is a function of their sales expectations and of the level of speculative liability already accepted (I_{t-1}). Equations (10) and (10a) are alternative explanations of the same phenomena.

The second remedy involves casting equation (9) immediately in the multiple linear regression form, which yields

(11d) $$ST_t = a_0 + a_1 S_t^e + a_2 (I_t^* - I_{t-1}) + \gamma_t ,$$

where a_0, a_1, and a_2 are regression coefficients and γ_t is the stochastic error term. By substituting for I_t^* according to equation (7) yields

(11e) $$ST_t = a_0 + (a_1+a_2A)S_t^e - a_2 I_{t-1} + \gamma_t .$$

Substituting for S_t^e according to equation (3) results in

(11f) $$ST_t = a_0 + (a_1+a_2A)(1+B)S_{t-1} - (a_1+a_2A)(B)S_{t-2} - a_2 I_{t-1} + \gamma_t .$$

Model 2-Equation (4)

Substituting into equation (10) for S_t^e according to equation (4) results in

(12a) $$ST_t = (1+A)[(C)S_{t-1} + (1-C)(C)S_{t-2} + (1-C)^2(C)S_{t-3} + (1-C)^3(C)\ S_{t-4} + \ldots] - I_{t-1} + \varepsilon_t .$$

However, the infinite number of regressors must somehow be reduced in order to estimate equation (12a). This is accomplished by the Koyck transformation,[4] which involves lagging equation (12a) by one period,

$$\text{(12b)} \qquad ST_{t-1} = (1+A)[(C)S_{t-2} + (1-C)(C)S_{t-3} + (1-C)^2(C)S_{t-4} + \ldots] - I_{t-2} + \varepsilon_{t-1},$$

multiplying (12b) by (1-C),

$$\text{(12c)} \qquad (1-C)ST_{t-1} = (1+A)[(1-C)(C)S_{t-2} + (1-C)^2(C)S_{t-3} + (1-C)^3(C)S_{t-4} + \ldots] - (1-C)I_{t-2} + (1-C)\varepsilon_{t-1},$$

and subtracting (12c) from (12a) to yield

$$\text{(12d)} \qquad ST_t - (1-C)ST_{t-1} = (1+A)(C)S_{t-1} - I_{t-1} + (1-C)I_{t-2} + \varepsilon_t - (1-C)\,\varepsilon_{t-1}.$$

Adding (1-C) ST_{t-1} to both sides of (12d) results in

$$\text{(12e)} \qquad ST_t = (1+A)(C)S_{t-1} + (1-C)\,ST_{t-1} - I_{t-1} + (1-C)\,I_{t-2} + \varepsilon_t - (1-C)\varepsilon_{t-1}.$$

Again I_{t-1} has no regression coefficient, but three remedies are available. The first is to add I_{t-1} to both sides of equation

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[4]Zvi Griliches, "Distributed Lags: A Survey," Econometrica, XXXV (January, 1967), p. 17.

(12e), which results in

$$\text{(12f)} \qquad ST_t + I_{t-1} = (1+A)(C)S_{t-1} + (1-C)ST_{t-1} + (1-C)I_{t-2} + \varepsilon_t - (1-C)\varepsilon_{t-1}.^5$$

The second remedy is to begin with equation (11e), assuming the multiple linear regression form, and substituting for S_t^e according to equation (4), which results in

$$\text{(12g)} \qquad ST_t = a_0 + (a_1+a_2A)[(C)S_{t-1} + (1-C)(C)S_{t-2} + (1-C)^2(C)S_{t-3} + (1-C)^3(C)S_{t-4} + \ldots] - a_2I_{t-1} + \eta_t \,.$$

Utilizing the Koyck transformation, by lagging (12g) one period,

$$\text{(12h)} \qquad ST_{t-1} = a_0 + (a_1+a_2A)[(C)S_{t-2} + (1-C)(C)S_{t-3} + (1-C)^2(C)S_{t-4} + \ldots] - a_2I_{t-2} + \eta_{t-1}\,,$$

multiplying through by (1-C),

$$\text{(12i)} \qquad (1-C)ST_{t-1} = a_0(1-C) + (a_1+a_2A)[(1-C)(C)S_{t-2} + (1-C)^2(C)S_{t-3} + (1-C)^3(C)S_{t-4} + \ldots] - a_2(1-C)I_{t-2} + (1-C)\,\eta_{t-1},$$

---

[5]The justification for equation (12f) is the same as for equation (11c).

and subtracting equation (12i) from equation (12g), results in

(12j) $$ST_t - (1-C)ST_{t-1} = a_0\ (C) + (a_1+a_2A)(C)S_{t-1} - a_2I_{t-1} + a_2(1-C)I_{t-2} + n_t - (1-C)\ n_{t-1}.$$

Adding (1-C) ST_{t-1} to both sides of equation (12j) results in

(12k) $$ST_t = a_0\ (C) + (a_1+a_2A)(C)S_{t-1} + (1-C)ST_{t-1} - a_2I_{t-1} + a_2\ (1-C)I_{t-2} + n_t - (1-C)n_{t-1}.$$

The third approach is to simplify equation (12e). This is accomplished by equation (12ℓ):

(12ℓ) $$I_{t+i} - I_{t-1+i} = ST_{t+i} - S_{t+i}\ ,$$

where i is equal to any integer or zero. Equation (12ℓ) states that the difference between starts and actual sales in any period (t+i) is equal to the change in inventory between period (t+i) and period (t-1 + i). If starts exceed sales, the change in inventory is positive; if sales exceed starts, the change in inventory is negative. This condition holds by definition.

Rearranging equation (12ℓ) and assuming i is equal to negative one, the following result is obtained:

(12m) $$ST_{t-1} + I_{t-2} = S_{t-1} + I_{t-1}.$$

Multiplying both sides by (1-C) results in

(12n) $$(1-C)ST_{t-1} + (1-C)I_{t-2} = (1-C)S_{t-1} + (1-C)I_{t-1} .$$

Equation (12e) contains, as independent variables,

$$(1-C)ST_{t-1} + (1-C)I_{t-2}.$$

Substituting, by equation (12n),

$$(1-C)S_{t-1} + (1-C)I_{t-1}$$

into equation (12e) results in

(12o) $$ST_t = (1+A)(C)S_{t-1} + (1-C)S_{t-1} - I_{t-1} + (1-C)I_{t-1} + \varepsilon_t - (1-C)\varepsilon_{t-1} ,$$

which simplifies to

(12p) $$ST_t = (AC+1)S_{t-1} - (C)I_{t-1} + \varepsilon_t - (1-C)\varepsilon_{t-1}.$$

<u>Model 3-Equation (5)</u>

Substituting into equation (10) for S_t^e according to equation (5) results in

(13a) $$ST_t = (1+A)(1+D)[S_{t-1} - (D)S_{t-2} + (D)^2S_{t-3} - (D)^3S_{t-4} + (D)^4S_{t-5} - \dots + \dots] - I_{t-1} + \theta_{t-1} .$$

The infinite number of regressors are again reduced by utilization of the Koyck transformation. Equation (13a) is first lagged one period to yield

(13b) $$ST_t = (1+A)(1+D)[S_{t-2} - (D)S_{t-3} + (D)^2S_{t-4} - (D)^3S_{t-5} + \ldots - \ldots] - I_{t-2} + \theta_{t-1} ,$$

which is multiplied by (D) to result in

(13c) $$(D)ST_{t-1} = (1+A)(1+D)[(D)S_{t-2} - (D)^2S_{t-3} + (D)^3S_{t-4} - (D)^4S_{t-5} + \ldots - \ldots] - (D)I_{t-2} + (D)\ \theta_{t-1} .$$

Equation (13c) is then added to equation (13a), which results in

(13d) $$ST_t + (D)ST_{t-1} = (1+A)(1+D)S_{t-1} - I_{t-1} - (D)I_{t-2} + \theta_t + (D)\ \theta_{t-1}.$$

Subtracting D ST_{t-1} from both sides of equation (13d) results in

(13e) $$ST_t = (1+A)(1+D)S_{t-1} - (D)ST_{t-1} - I_{t-1} - (D)I_{t-2} + \theta_t + (D)\theta_{t-1}.$$

Again, however, I_{t-1} has no regression coefficient. The three methods of remedying this condition are the same as those utilized for Model 2. The first is to add I_{t-1} to both sides of (13e), which results in

$$\text{(13f)} \qquad ST_t + I_{t-1} = (1+A)(1+B)S_{t-1} - (D)ST_{t-1} - (D)I_{t-2} + i_t + (D)i_{t-1}.^{6}$$

The second remedy is to develop the model beginning with the multiple linear regression form. Beginning with equation (11e) and substituting for S_t^e according to equation (5), one obtains

$$\text{(13g)} \qquad ST_t = a_0 + (a_1+a_2A)(1+D)[S_{t-1} - (D)S_{t-2} + (D)^2S_{t-3} - (D)^3S_{t-4} + (D)^4S_{t-5} - \ldots + \ldots] - a_2I_{t-1} + \kappa_t.$$

Again applying the Koyck transformation, by lagging (12g) one period,

$$\text{(13h)} \qquad ST_{t-1} = a_0 + (a_1+a_2A)(1+D)[S_{t-2} - (D)S_{t-3} + (D)^2S_{t-4} - (D)^3S_{t-5} + \ldots - \ldots] - a_2I_{t-2} + \kappa_{t-1},$$

multiplying equation (13h) by (D),

$$\text{(13i)} \qquad (D)ST_{t-1} = a_0\,(D) + (a_1+a_2A)(1+D)[(D)S_{t-2} - (D)^2S_{t-3} + (D)^3S_{t-4} - (D)^4S_{t-5} + \ldots - \ldots] - a_2\,(D)I_{t-2} + (D)\kappa_{t-1},$$

---

[6]The justification for equation (13f) is the same as for equation (11c).

and adding (13i) to (13g) results in

(13j) $$ST_t + (D)ST_{t-1} = a_0\ (1+D) + (a_1+a_2A)(1+D)S_{t-1}$$

$$- a_2I_{t-1} - a_2(D)I_{t-2} + \kappa_t + (D)\kappa_{t-1}.$$

Subtracting $(D)ST_{t-1}$ from both sides of equation (13j) results in

(13k) $$ST_t = a_0\ (1+D) + (a_1+a_2A)(1+D)S_{t-1} - (D)ST_{t-1}$$

$$- a_2I_{t-1} - a_2\ (D)I_{t-2} + \kappa_t + (D)\kappa_{t-1}.$$

The third remedy involves substituting for ST_{t-1} and I_{t-2} in equation (13e). Multiplying equation (12m) by (-D) results in

(13ℓ) $$-(D)ST_{t-1} - (D)I_{t-2} = -(D)S_{t-1} - (D)I_{t-1}.$$

By substituting the right side of equation (13ℓ) into (13e) for $((-D)ST_{t-1} - (D)I_{t-2})$ results in

(13m) $$ST_t = (1+A+AD)S_{t-1} - (1+D)I_{t-1} + \lambda_t + (D)\lambda_{t-1}.$$

ESTIMATION AND ESTIMATION DIFFICULTIES

Expectations Regarding the Partial Regression Coefficients

A summary of the equations to be estimated by ordinary least squares is given in Table 1, with the reduced forms given in Table 2. The expected signs of the partial regression coefficients are as indicated by Table 2 with all of the A's, B's, C's, ..., H's being

Table 1

Summary of Estimable Equations

Model 1

(11c) $$ST_t + I_{t-1} = (1+A)(1+B)S_{t-1} - B(1+A)S_{t-2} + \beta_t$$

(11f) $$ST_t = a_o + (a_1+a_2A)(1+B)S_{t-1} - B(a_1+a_2A)S_{t-2} - a_2I_{t-1} + \gamma_t$$

Model 2

(12f) $$ST_t + I_{t1} = (1+A)CS_{t-1} + (1-C)ST_{t-1} + (1-C)I_{t-2} + \int_t - (1-C)\int_{t-1}$$

(12k) $$ST_t = a_oC + (a\ + a_2A)CS_{t-1} + (1-C)ST_{t-1} - a_2\ I_{t-1} + a_2\ (1-C)\ I_{t-2} + \eta_t - (1-C)\ \eta_{t-1}$$

(12p) $$ST_t = (AC+1)S_{t-1} - CI_{t-1} + e_t - (1-C)e_{t-1}$$

Model 3

(13f) $$ST_t + I_{t-1} = (1+A)(1+D)S_{t-1} - DST_{t-1} - DI_{t-2} + i_t + Di_{t-1}$$

(13k) $$ST_t = a_o\ (1+D)+(a + a_2A)(1+D)S_{t-1} - DST_{t-1} - a_2\ I_{t-1} - a_2\ DI_{t-2} + K_t + DK_{t-1}$$

(13m) $$ST_t = (1+A+AD)S_{t-1} - (1+D)\ I_{t-1} + \lambda_t + D\lambda_{t-1}$$

Table 2

Summary of Estimable Equations - Reduced Form

Model 1

(11c) $$ST_t + I_{t-1} = A_o S_{t-1} - A_1 S_{t-2} + \beta_t$$

(11f) $$ST_t = B_o + B_1 S_{t-1} - B_2 S_{t-2} - B_3 I_{t-1} + \nu_t$$

Model 2

(12f) $$ST_t + I_{t-1} = C_o S_{t-1} + C_1 ST_{t-1} + C_2 I_{t-2} + \mu_t$$

(12k) $$ST_t = D_o + D_1 S_{t-1} + D_2 ST_{t-1} - D_3 I_{t-1} + D_4 I_{t-2} + \nu_t$$

(12p) $$ST_t = E_o S_{t-1} - E_1 I_{t-1} + \xi_t$$

Model 3

(13f) $$ST_t + I_{t-1} = F_o S_{t-1} - F_1 ST_{t-1} - F_2 I_{t-2} + \pi_t$$

(13k) $$ST_t = G_o + G_1 S_{t-1} - G_2 ST_{t-1} - G_3 I_{t-1} - G_4 I_{t-2} + \gamma t$$

(13m) $$ST_t = H_o S_{t-1} - H_1 I_{t-1} + \phi_t$$

greater than zero.

It should be noticed that the same independent variables with identical lag structures are present in all equations for Models 2 and 3. The method of differentiation between Models 2 and 3 is the difference in signs of the partial regression coefficients for ST_{t-1} and I_{t-2}, which would be negative if Model 3 were appropriate and positive if Model 2 were appropriate. This criterion fails, however, for equations (12p´) and (13m´), where identical signs are hypothesized for both models. The only possible method of distinguishing between appropriateness of the two models based on equations (12p´) and (13m´) would be to have some prior knowledge of A, the ratio of desired inventory to expected sales. This would involve comparing levels of A derived from (12p) and (13m) with an estimate of the actual value of A.

Although it would be preferable to compare the magnitudes of the partial regression coefficients to a priori expectations, there are reasons to doubt the usefulness of this activity. These reasons are discussed in the following paragraphs.

Estimation Difficulties Expected

Multicollinearity. One assumption of the multiple linear regression model is that none of the independent variables be perfectly correlated with another independent variable or with any linear combination of the other independent variables.

When this condition is violated, the separate influences of the perfectly correlated independent variables cannot be separated and the estimation procedure fails.

A high degree of multicollinearity is said to be present when an independent variable is highly correlated with another independent variable or with a combination of independent variables.[7]

If the phenomenon being investigated closely approximates the assumptions of the multiple linear regression model, the sample partial regression coefficients are best linear unbiased estimators (BLUE) of the population partial regression coefficients. With a high degree of multicollinearity existing between any independent variables, the variances of the sampling distribution of the partial regression coefficients for those intercorrelated variables are larger compared to the case where little or not milticollinearity exists. As the degree of multicollinearity approaches perfect multicollinearity, these variances approach infinity. While the variances of the sampling distribution of the partial regression coefficients are still "best" (minimum variance of all possible variances), these variances are so great that the estimates of the partial regression coefficients are unreliable. A precise estimate of the relative effects of the separate independent variables cannot be obtained. If one desired to test the hypothesis that the value of the sample partial regression coefficient is significantly different from any alternative values, the larger the variance of the sampling distribution of the partial regression coefficient, the more likely the test will fail.

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[7]For a discussion of the effects of multicollinearity on ordinary least squares estimates, see Jan Kmenta, Elements of Econometrics (New York: The Macmillan Company, 1971), pp. 380-391.

The threat of multicollinearity exists in this study because several equations contain independent variables that differ only in the number of periods lagged. An example is equation (11c´), which contains sales lagged one period and sales lagged two periods. If the time period covered by the data is dominated by either gradual growth or gradual decline, S_{t-1} and S_{t-2} will probably be highly correlated. It is likely in this case that all explanatory variables be highly correlated.

If parameter estimates vary greatly due to changes in the data employed or due to changes in specification of the model, it might be suspected that a high degree of multicollinearity exists.

Serial correlation - model 1. The assumption of no serial correlation implies that disturbances occurring in one period do not affect disturbances occurring in the succeeding period, or

(14) $$E\,(\varepsilon_i \varepsilon_j) = 0, \text{ for all } i \neq j.$$

If disturbances in period (i) do affect disturbances in period (j), the value of the stochastic error term, ε_j, will have some dependence upon ε_i, the error term of the preceding period. The shorter the time period between observations, the more likely it is that the disturbances will be serially correlated.

In the multiple linear regression model, violation of the assumption of no serial correlation will lead to biased estimates of the variances of the partial regression coefficients.[8] The direction of the bias will depend upon whether the serial correlation will cause the sample variances to underestimate the population variances, whereas negative serial correlation causes an upward bias. If one desires to test the hypothesis that a sample partial regression coefficient is different from any alternative value of that coefficient, underestimation of the population variance will result in reaching a positive conclusion more often than if no bias was present. The opposite is true of serial correlation were negative.

The presence of serial correlation, while not biasing the estimates of the partial regression coefficients themselves, necessarily reduces the confidence one can place in those estimates.

Serial correlation and lagged dependent variables - models 2 and 3. The application of the Koyck transformation to eliminate the infinite number of regressors introduces two problems into the estimation procedure. The first is that starts lagged one period has been introduced as an explanatory variable in equations (12f), (12k), (13f) and (13k), although the variable is theoretically irrelevant. The second problem is that the disturbance term in all equations but (11c) and (11f) explicitly indicates that disturbances in the current period are partly a function of disturbances in the previous time period. An example from Model 2 is equations (12f) and (12f′) by which the total disturbance υ_t is equal to $(\zeta_t - m\zeta_{t-1})$, where me is equal to (1-C).

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[8] A summary of the effects of serial correlation on ordinary least squares estimates is found in J. Johnston, Econometric Methods 1st ed. (New York: McGraw-Hill, 1963), p. 179.

Examples from Model 3 are equations (13f) and (13f′) by which π_t is equal to $(i_t + Di_{t-1})$.

The lagged dependent variable appearing as an independent variable will, by itself, produce biased estimates of the sample partial regression coefficients. The direction of the bias will be negative. Serial correlation, by itself, will not produce biased estimates, but the combination of the lagged dependent variable and serial correlation will lead to positively biased, inconsistent estimates of the partial regression coefficients.[9] Equation (10) of the general model hypothesized that the disturbance term, α_t, is normally distributed, serially independent as hypothesized by equation (14), that its values are independent of the values of the explanatory variables, that its expected value is zero, and that it has a constant variance. After application of the Koyck transformation, the new disturbance term, ψ_t, defined by (15) $\psi_t = \alpha_t + \eta\, \alpha_{t-1}$ where η is any real non-zero number, will exhibit serial correlation even if α_t is serially independent, as hypothesized.

Whereas serial correlation in Model 1 leads to biased estimates of the variances of the partial regression coefficients, serial correlation in Models 2 and 3 leads to inconsistent estimates of the partial regression coefficients themselves.

The level of difficulty in interpreting estimates is compounded

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[9]A discussion of the combined effects of serial correlation and lagged dependent variables is found in J. Johnston, Econometric Methods 2nd ed. (New York: McGraw-Hill, 1972), pp. 300-315.

by the presence of the dependent variable lagged one period appearing as an independent variable. This is the second by-product of the Koyck transformation. Whereas in Model 1 one can hypothesize that the disturbance term, α_t, is independent of the explanatory variables, Models 2 and 3 make explicit the lack of independence of the error term ($\alpha_t + n\alpha_{t-1}$) and starts lagged one period. This lack of independence will cause biased estimates of population parameters.

CHARACTERISTICS AND SOURCES OF THE DATA

Each of the three data series discussed below is in terms of "units of housing." As stated previously this author acknowledges that dollar or real measurement is preferred when measuring the level of financial liability and additions to and subtractions from that level of liability. Unfortunately, in the absence of these preferred measures, housing units must be treated homogeneously.

Starts

Estimates of starts of private single family housing units are published monthly.[10] An implied assumption of the models used in this study is that all single family housing units started are intended for sales, but units intended for rental use, units built by their owner, and units built by contractors on land owned by the buyer are included in estimates of starts. The inability to remove the data starts

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[10] U.S. Department of Commerce, Bureau of the Census, C-20, Housing Starts (Washington: U.S. Government Printing Office, monthly).

arising from these sources, which would yield estimates of starts intended only for sale, constitutes a limitation of the analysis. The limitation would be mitigated to the extent that the level of units started for purposes other than sales are either constant or fluctuate with starts of units intended for sale, but there is no a priori reason to support these possibilities. While the source of bias is clear, the direction of the bias is not.

Sales

Estimates of sales of new private single family housing units are published monthly.[11] These estimates are based upon a subsample selected from the sample used to estimate housing starts.

Inventory

In order to be consistent with its theoretical base, the inventory data should include all unsold completed units and unsold units under construction. Estimates of the number of houses for sale are published monthly.[12] However, the data also includes homes for sale which are not started, but for which a building permit has been obtained. This inroduces the tendency to overestimate inventories, given that the theoretical variable is intended to measure builders' liabilities. The percentage of houses for sale but not started has steadily increased

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[11]U.S. Department of Commerce, Bureau of the Census, C-25, Sales of New One-Family Homes (Washington: U.S. Government Printing Office, monthly).

[12]U.S. Department of Commerce, Bureau of the Census, C-25, Sales of New One-Family Homes (Washington: U.S. Government Printing Office, monthly).

from eight percent in 1963 to 16 percent in 1971.[13]

Period of Estimation

The three models are tested on four sets of data, monthly data unadjusted for seasonal variation from January 1965 to December 1971, monthly data seasonally adjusted from January 1969 to December 1971, quarterly data unadjusted for seasonal variation from the first quarter of 1965 to the last quarter of 1971, and quarterly adjusted data from the first quarter of 1969 to the last quarter of 1971.[14]

Expectations by Data Samples

The adaptive expectation model is more appropriately tested on seasonally adjusted data to the extent that builders recognize seasonal variation and plan their construction schedule accordingly. For example, builders will not base fourth quarter sales expectations solely upon third quarter sales levels if they recognize significant seasonal variations. This author expects builders to recognize seasonal variations. Therefore, seasonally adjusted data should provide more accurate specification of the parameters for each of the models.

This author utilized both monthly and quarterly data to represent the time period between builders' revaluations of their sales performance and sales expectations. Which time period is more appropriate?

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[13]Estimates of "houses for sale, not started," are unavailable from July 1967 to November 1970. This prevents exclusion of this category from the entire sample.

[14]The author attempted to obtain data, adjusted and unadjusted, covering the period from 1963 to the present. As of this writing, the data has not arrived.

One might expect builders to react more stongly to quarterly changes than to monthly changes on the basis that monthly variations are more subject to random disturbances.

On the other hand, quarterly changes may be due to unusually high or low levels of sales early in the quarter, but levels of sales later in the quarter yield expectations different from those generated by considering the entire quarter. The issue is still cloudy. The ability of the author to test these two alternatives is limited by the small number of observations on quarterly adjusted data.

Chapter 3

EMPIRICAL RESULTS

Tables 3 through 7 summarize the empirical results for each equation. For a given equation, the variation in the values of the partial regression coefficients is substantial as different data samples are employed. This leads one to suspect a high degree of multicollinearity, a suspicion which is confirmed by the correlation matrix for each data sample, especially for seasonally adjusted data (see Tables 8-11). As a result, the high values of the variances of the partial correlation coefficients are reflected in lower values of the computed t value.

The Durbin-Watson Statistic is only reported for equations (11c) and (11f). Where the disturbance term takes the form specified by equation (15), the Durbin-Watson statistics is biased toward values indicating no serial correlation.[1]

MODEL 1

Equation (11c)

The empirical estimates for equation (11c) are summarized in Table 3. The hypothesized signs of the partial regression coefficients for S_{t-2} differ from the estimated signs for three of the four data

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[1]J. Johnston, Econometric Methods, 2nd ed. (New York: McGraw-Hill, 1972), p. 307.

Table 3 - Equation (11c)

Model 1 - $ST_t + I_{t-1}$ Dependent

Type of Data / Degrees of Freedom		Monthly Unadjusted 78	Monthly Adjusted 30	Quarterly Unadjusted 23	Quarterly Adjusted 6
Sales Lagged	Partial Regression Coefficient	2.06	2.12	3.02	0.42
One Period	Computed T Value	4.70	2.37	4.81	0.33
Sales Lagged	Partial Regression Coefficient	1.16	0.91	-0.65	3.25
Two Periods	Computed T Value	2.64	0.95	-0.98	2.29
Intercept		152.36	172.14	187.16	153.23
Coefficient of Determination		0.69	0.67	0.56	0.87
Durbin-Watson Statistic		0.40	0.46	0.97	3.10

Table 4 - Equation (11f)

Model 1 - ST_t Dependent

Type of Data Degrees of Freedom		Monthly Unadjusted 78	Monthly Adjusted 30	Quarterly Unadjusted 23	Quarterly Adjusted 6
Sales Lagged One Period	Partial Regression Coefficient	1.78	1.09	2.28	1.52
	Computed T Value	8.48	3.29	8.00	2.53
Sales Lagged Two Periods	Partial Regression Coefficient	0.32	0.45	-1.59	0.34
	Computed T Value	1.48	1.29	-5.20	0.41
Inventory Lagged One Period	Partial Regression Coeeficient	-0.09	0.09	0.11	0.06
	Computed T Value	-1.53	2.22	0.94	0.29
Intercept		3.49	-32.62	21.39	-14.87
Coefficient of Determination		0.80	0.85	0.78	0.93
Durbin-Watson Statistic		1.31	1.72	1.75	2.01

Table 5 - Equations (12f) & (13f)

Model (3 & 2) - $ST_t + I_{t-1}$ Dependent

Type of Data		Monthly Unadjusted	Monthly Adjusted	Quarterly Unadjusted	Quarterly Adjusted
Degrees of Freedom		78	30	23	6
Sales Lagged One Period	Partial Regression Coefficient	1.30	0.46	2.92	0.72
	Computed T Value	5.25	1.60	3.66	0.62
Starts Lagged One Period	Partial Regression Coefficient	0.47	0.84	-0.47	1.18
	Computed T Value	4.41	4.96	-1.34	1.61
Inventory Lagged Two Periods	Partial Regression Coefficient	0.90	1.14	0.67	1.09
	Computed T Value	13.43	11.42	3.24	2.43
Intercept		7.13	-35.63	55.44	-57.43
Coefficient of Determination		0.90	0.96	0.73	0.93

Table 6 - Equations (12k) & (13k)

Models 2 and 3 - ST_t Dependent

Type of Data Degrees of Freedom		Monthly Unadjusted 77	Monthly Adjusted 29	Quarterly Unadjusted 22	Quarterly Adjusted 6
Sales Lagged One Period	Partial Regression Coefficient	1.74	0.89	3.42	2.08
	Computed T Value	8.46	2.52	7.50	2.77
Starts Lagged One Period	Partial Regression Coefficient	0.15	0.45	-1.03	-0.30
	Computed T Value	1.60	1.77	-4.84	-0.53
Inventory Lagged One Period	Partial Regression Coefficient	0.30	- 0.15	0.35	0.36
	Computed T Value	1.58	- 0.34	1.81	0.98
Inventory Lagged Two Periods	Partial Regression Ceofficient	-0.40	0.29	-0.48	-0.31
	Computed T Value	-2.05	0.64	-2.37	-0.69
Intercept		10.57	-26.91	32.87	0.95
Coefficient of Determination		0.82	0.86	0.77	0.94

Table 7 - Equations (12p) & (13m)

Models 2 and 3 with Substitution - ST_t dependent

Type of Data Degrees of Freedom		Monthly Unadjusted 79	Monthly Adjusted 31	Quarterly Unadjusted 2	Quarterly Adjusted 7
Sales Lagged One Period	Partial Regression Coefficient	2.02	1.47	1.60	1.74
	Computed T Value	15.83	8.66	4.27	6.30
Inventory Lagged One Period	Partial Regression Coefficient	-0.06	0.20	-0.08	0.12
	Computed T Value	-1.20	2.33	-0.50	0.82
Intercept		2.32	-31.8	23.4	-22.9
Coefficient of Determination		0.79	0.84	0.50	0.93

Table 8

Correlation Matrix - Monthly Data Unadjusted For Seasonal Variation

	ST_t	S_{t-1}	I_{t-1}	ST_{t-1}	S_{t-2}	I_{t-2}	$ST_t + I_{t-1}$
ST_t							
S_{t-1}	.89						
I_{t-1}	.36	.46					
ST_{t-1}	.82	.84	.46				
S_{t-2}	.78	.84	.50	.89			
I_{t-2}	.30	.44	.96	.37	.46		
$ST_t + I_{t-1}$	.81	.81	.83	.78	.78	.77	

Table 9

Correlation Matrix - Monthly Data Adjusted
For Seasonal Variation

	ST_t	S_{t-1}	I_{t-1}	ST_{t-1}	S_{t-2}	I_{t-2}	$ST_t + I_{t-1}$
ST_t							
S_{t-1}	.90						
I_{t-1}	.68	.60					
ST_{t-1}	.89	.88	.71				
S_{t-2}	.87	.91	.58	.89			
I_{t-2}	.64	.58	.97	.61	.52		
$ST_t + I_{t-1}$	.91	.82	.92	.87	.78	.88	

Table 10

Correlation Matrix - Quarter Data Unadjusted For Seasonal Variation

	ST_t	S_{t-1}	I_{t-1}	ST_{t-1}	S_{t-2}	I_{t-2}	$ST_t + I_{t-1}$
ST_t							
S_{t-1}	.70						
I_{t-1}	.28	.49					
ST_{t-1}	.34	.84	.46				
S_{t-2}	-.01	.59	.51	.70			
I_{t-2}	.19	.40	.83	.24	.40		
$ST_t + I_{t-1}$	.78	.74	.82	.50	.33	.65	

Table 11

Correlation Matrix - Quarterly Data Adjusted For Seasonal Variation

	ST_t	S_{t-1}	I_{t-1}	ST_{t-1}	S_{t-2}	I_{t-2}	$ST_t + I_{t-1}$
ST_t							
S_{t-1}	.96						
I_{t-1}	.68	.64					
ST_{t-1}	.93	.95	.78				
S_{t-2}	.92	.91	.79	.95			
I_{t-2}	.42	.40	.86	.53	.52		
$ST_t + I_{t-2}$	.92	.87	.92	.93	.93	.70	

samples employed. Sales lagged one period has the hypothesized direction of influence in all cases.

There is evidence of positive serial correlation in three cases, which causes the reported t values to be overestimated. The negative serial correlation on quarterly adjusted data results in understatement of computed t values.

This equation results in the lowest coefficients of determination for each data sample, with one exception, quarterly unadjusted data.

Equation (11f)

The empirical estimates of equation (11f) are summarized in Table 4. The change in specification from equation (11c) does not improve the conformance of the estimated regression coefficients to the hypothesized direction of influence. S_{t-2} and I_{t-1} have negative partial regression coefficients only once, each in a different data sample. The change in specification apparently reduced serial correlation in all cases, "apparently" because if auto correlation and errors in measurement of the independent variables are present, the Durbin-Watson statistic is not a reliable measure of the degree of serial correlation.[2] Also, the coefficient of determination is improved for

[2]For a discussion of errors in variables and autocorrelation, see Jan Kmenta, Elements of Econometrics (New York: The Macmillan Company, 1971), pp. 307-308, and Zvi Griliches, "Distributed Lags: A Survey," Econometrica, XXXV, (January, 1967), pp. 33-42.

each data sample.

Conclusions - Model 1

The evidence supports the conclusion that Model 1 does not properly specify how builders form sales expectations. However, the results tend to support the hypothesis that builders' expectations are formed on the basis of their sales performance.

The hypothesized inventory adjustment mechanism is not supported by the evidence.

One must remember that the evidence, or data samples, is in unit terms, whereas data in dollar or real terms is preferred. Therefore, acceptance or rejection of Model 1, and the inventory adjustment mechanism should be postponed until data in dollar or real terms is available.

MODEL 2

Equation (12f)

The empirical estimates for equation (12f) are summarized in Table 5. The signs of the partial correlation coefficients do conform with a priori expectations on all data samples with the exception of ST_{t-1} on quarterly unadjusted data.

The coefficients of determination for monthly data are the highest reported in this study.

Equation (12k)

Appearing as an independent variable, I_{t-1} carries the hypothesized negative regression coefficient only once of four occasions. The introduction of I_{t-1} on the right side of the equation causes the sign of the partial regression coefficient of I_{t-2} to be negative on those occasions where the sign of I_{t-1} is positive. In addition, the direction of influence of ST_{t-1} becomes negative on quarterly data. As a result, only on monthly adjusted data are the signs of all the partial regression coefficients in accordance with expectations.

Compared to equation (12f) the coefficients of determination are lower on monthly data, but marginally higher on quarterly data.

Equation (12p)

The empirical estimates for equation (12p) are summarized in Table 7. Inventory lagged one period performed in accordance with a priori expectations only on unadjusted data. The elimination of ST_{t-1} and I_{t-2} reduced the coefficient of determination substantially only on quarterly unadjusted data. One might have more confidence in these estimates, compared to equation (12k), since a source of bias has been removed.

Conclusions - Model 2

The evidence neither supports nor denies the expectation mechanism hypothesized by Model 2. Whereas the evidence supports the inventory adjustment mechanism in explaining the total level of liability builders are willing to incur, the evidence does not support the inventory adjustment mechanism in explaining changes in the total level of liability.

The limitations of the evidence, discussed in reference to

Model 1, also apply to Model 2.

MODEL 3

Equation (13f)

The empirical estimates of equation (13f) are summarized in Table 5. This equation is the same as (12f) except that negative signs are hypothesized for the partial regression coefficients of ST_{t-1} and I_{t-2}. This did not occur.

Equation (13k)

The empirical estimates for equation (13k) are summarized in Table 6. Inventory lagged one period carries the hypothesized negative sign for the partial regression coefficients only once, while I_{t-2} conforms with expectations on three of four occasions. ST_{t-1} conforms with expectations only on quarterly data.

Equation (13m)

The empirical estimates for equation (13m) are summarized in Table 7. The reader should refer to the discussion of equation (12p).

Conclusions - Model 3

The failure of the signs of the partial regression coefficients of ST_{t-1} and I_{t-2} to conform with expectations in most cases supports the rejection of Model 3. The failure of I_{t-1} to conform with the expected negative sign supports the rejection of the inventory adjustment mechanism.

The limitations of the evidence, discussed in reference to

Model 1, also apply to Model 3.

Chapter 4

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

Equations (12p) and (13m) indicate that the sales variable lagged one period substantially explains short run fluctuations in single family housing unit starts. Exceptionally good fits were achieved when employing quarterly data adjusted for seasonal variation with starts in the current period as the dependent variable.

From the results achieved in the study it appears that expected sales, and therefore housing starts, depend upon an adaptive expectations mechanism which is based partly upon actual unit sales in the previous time period. However, the evidence does not provide a clear indication of the exact specification of the adaptive process.

When inventories lagged one time period was used as an independent variable, the sign of the partial regression coefficient did not possess the a priori properties anticipated. The signs of the partial regression coefficients were positive in eight of twelve cases.

For models 2 and 3, when starts in the current period (ST_t) plus inventories lagged one time period (I_{t-1}) was utilized as the dependent variable, good fits were achieved when employing monthly data. The evidence does not provide a clear indication of the exact specification of the inventory adjustment mechanism.

Acceptance or rejection of any of the three models should be deferred until further analysis can be accomplished.

RECOMMENDATIONS

Data Base Requirements

When unit data is employed, the implicit assumption is made that housing units can be treated homogeneously. The assumption distorts sales and inventory coefficients of the models. The builder is concerned with the financial liability incurred in carrying his inventory. The purchaser is concerned with the price of the housing unit. Therefore, as stated previously, sales and inventory variables should be expressed in nominal or real terms. At present, data regarding these variables are collected only in unit terms. Monthly data should be collected on sales, completions, starts, and inventories in dollar terms. Seasonally adjusted and deflated series should be developed for each of the above categories.[1]

This analysis was severely limited by unavailability of data, especially of data adjusted for seasonal variation. When more observations of the variables used in this study are available in seasonally

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[1]A number of additional housing series are to be implemented in the present fiscal year. However, the four series suggested above are not included in the new series. Land values should be included in the sales and inventory figures since land cost constitutes a large percentage of the financial liability incurred by builders in maintaining an inventory and a large percentage of the sales price to buyers. See the Executive Office of the President, Office of Management and Budget, Statistical Reporter (Washington: U.S. Government Printing Office, monthly), No. 72-8 (February, 1972), p. 136.

adjusted form, the author suggests that the analysis be reaccomplished.

Additionally, the author suggests that the models be specified utilizing regional or standard metropolitan statistical area (SMSA) data. Aggregation of data probably biases the estimates of expectation coefficients and of the ratio of desired inventory to expected sales (A).

Respecification of the Model

The assumption that builders' current sales expectations depend solely upon previous levels of actual sales may be too restrictive. The possibility exists that builders' perceptions of future sales may be conditioned by other factors. For example, even though actual sales in the previous period were less than expected, builders may still raise their sales expectations in the current period because of easing credit conditions or because of increases in housing rents and prices relative to construction costs. These factors can be introduced into the adaptive expectation models developed in this study by utilizing variable expectation coefficients. The variable expectation coefficients could also be allowed to assume values greater than unity.

The assumption that the level of inventory desired by builders depends only upon the level of expected sales (for a given length of the construction period) may also exclude other relevant determinants. Specifically, a builder's ability to carry a given level of inventory is a function of the cost and availability of credit. An alternative specification of the level of desired inventory might be to make the ratio of desired inventory to expected sales (A) a function of the cost and availability of credit.

The model of inventory adjustment utilized in this study assumed attempted complete adjustment. When large unexpected changes in sales occur, it is possible that builders cannot attempt to reach equilibrium positions by the end of the current period. The shorter the period between observations, the more this is the case. Therefore, a partial adjustment inventory model might be utilized.[2]

Additional research should include an attempt to construct "just-identified" models so that specification of the structural parameters from the reduced form is possible.[3]

The model might also be extended to include multi-unit structures and mobile homes.

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[2]Jan Kmenta, Elements of Econometrics (New York: The Macmillan Company, 1971), p. 476.

[3]Edward J. Kane, Economic Statistics and Econometrics: An Introduction to Quantitative Economics (New York: Harper and Row, 1968), pp. 325-329.

BIBLIOGRAPHY

Ackley, Gardner. Macroeconomic Theory. New York: The Macmillan Company, 1961.

Alberts, William W. "Business Cycles, Residential Construction Cycles, and the Mortgage Market," Journal of Political Economy, LXX (June, 1962), 263-281.

Bober, Stanley. The Economics of Cycles and Growth. New York: John Wiley and Sons, Inc., 1968.

Chao, Lincoln L. Statistics: Methods and Analyses. New York: McGraw-Hill, 1969.

Commission on Money and Credit. Impacts of Monetary Policy. Englewood Cliffs: Prentice-Hall, Inc., 1963.

Derksen, J.B.D. "Long Cycles in Residential Building: An Explanation," Econometrica, VIII (April, 1940), 97-116.

Evans, Michael K. Macroeconomic Activity. New York: Harper & Row, Publishers, 1969.

Ferguson, C. E. Microeconomic Theory. Homewood: Richard D. Irwin, Inc., 1966.

Friedman, Bernard N. "Private Housing Completions: A New Dimension in Construction Statistics," Staff Economic Studies of the Board of Governors of the Federal Reserve System, LXVI (January, 1972).

Goldfinger, Nat. "Labor Costs and the Rise in Housing Prices," Monthly Labor Review, XCIII (Dec., 1970), 60-61.

Griliches, Zvi. "Distributed Lags: A Survey," Econometrica, XXXV (January, 1967), 16-49.

Harberger, Arnold C. (ed.). The Demand for Durable Goods. Chicago: The University of Chicago Press, 1960.

Johnston, J. Econometric Methods, 1st ed. New York: McGraw-Hill, 1963.

______. Econometric Methods, 2nd ed. New York: McGraw-Hill, 1972.

Josowitz, Aaron. "Housing Statistics: Published and Unpublished," Monthly Labor Review, XCII (December, 1969), 52-55.

BIBLIOGRAPHY

Ackley, Gardner. Macroeconomic Theory. New York: The Macmillan Company, 1961.

Alberts, William W. "Business Cycles, Residential Construction Cycles and the Mortgage Market," Journal of Political Economy, LXX (June, 1962), 263-281.

Bober, Stanley. The Economics of Cycles and Growth. New York: John Wiley and Sons, Inc., 1968.

Chao, Lincoln L. Statistics: Methods and Analyses. New York: McGraw-Hill, 1969.

Commission on Money and Credit. Impacts of Monetary Policy. Englewood Cliffs: Prentice-Hall, Inc., 1963.

Derksen, J.B.D. "Long Cycles in Residential Building--An Explanation," Econometrics, VIII (April, 1940), 97-116.

Evans, Michael K. Macroeconomic Activity. New York: Harper & Row, Publishers, 1969.

Ferguson, C.E. Microeconomic Theory. Homewood: Richard D. Irwin, Inc., 1966.

Freedman, Bernard N. "Private Housing Completions--A New Dimension in Construction Statistics," Staff Economic Studies of the Board of Governors of the Federal Reserve System, LXVI (January, 1972).

Goldfinger, Nat. "Labor Costs and the Rise in Housing Prices," Monthly Labor Review, XCIII (May, 1970), 60-62.

Griliches, Zvi. "Distributed Lags: A Survey," Econometrica, XXXV (January, 1967), 16-49.

Harberger, Arnold C. (ed.). The Demand for Durable Goods. Chicago: The University of Chicago Press, 1960.

Johnston, J. Econometric Methods, 1st ed. New York: McGraw-Hill, 1963.

________. Econometric Methods. 2nd ed. New York: McGraw-Hill, 1972.

Josowitz, Aaron. "Housing Statistics: Published and Unpublished," Monthly Labor Review, XCII (December, 1969), 50-55.

Kane, Edward J. Economic Statistics and Econometrics: An Introduction to Quantitative Economics. New York: Harper & Row, 1968.

Kmenta, Jan. Elements of Econometrics. New York: The Macmillan Company, 1971.

Maisel, Sherman J. "A Theory of Fluctuations in Residential Construction Starts," American Economic Review, LIII (June, 1963), 359-383.

Smith, Lawrence B. "A Model of Canadian Housing and Mortgage Markets," Journal of Political Economy, LXXVII (September-October, 1969), 795-816.

U.S. Department of Commerce. C-20, Housing Starts. Washington: U.S. Government Printing Office, January 1965-December 1971.

________. C-25, Sales of New One Family Homes. Washington: U.S. Government Printing Office, January 1965-December 1971.

U.S. Executive Office of the President. Statistical Reporter. Washington: U.S. Government Printing Office, January 1971.