#418-77

INSTITUTE FOR RESEARCH ON POVERTY DISCUSSION PAPERS

HOUSING SUPPLY POLICIES: AN EXAMINATION OF PARTIAL EQUILIBRIUM IMPACTS IN A METROPOLITAN AREA

Katharine Bradbury

UNIVERSITY OF WISCONSIN ~ MADISON

Housing Supply Policies: An Examination of Partial Equilibrium Impacts in a Metropolitan Area

Katharine Bradbury

May 1977

The research reported herein was partially supported by funds granted to the Institute for Research on Poverty at the University of Wisconsin-Madison by the Department of Health, Education, and Welfare pursuant to the provisions of the Economic Opportunity Act of 1964. The author gratefully acknowledges the helpful comments of Jerome Rothenberg and Robert F. Engle on earlier work on which this paper is based.

ABSTRACT

An econometrically-estimated model is used to simulate the partial-equilibrium effects of several policies on decade changes in housing supply in a multi-zoned metropolitan area. The six-equation model predicts changes in the number of housing units by structure type and mode of supply (new construction and alteration or withdrawal of existing units) for eighty-nine geographic zones in the Boston metropolitan area for the 1960-1970 decade. The policies which are simulated include the elimination of two kinds of residential zoning restrictions, the provision of sewers to all housing units in each jurisdiction, a policy of "eminent domain" to produce vacant land from land previously in nonresidential use, and a subsidy to new housing construction. The results of the simulations indicate the direction of response of the zonal quantities of housing to the policies. Discussion is focused on the geographic pattern of those responses.

Housing Supply Policies: An Examination of Partial Equilibrium Impacts in a Metropolitan Area

One concern often overlooked in the analysis of various policies affecting the supply of urban housing is geographic variation in response and impact. This is of particular concern to central city policy makers who have observed the increasing decentralization of residence patterns in the nation's metropolitan areas and wish to evaluate proposed policies (not only those relating to housing) in terms of their potential impact on this trend. With a few exceptions (most notably, DeLeeuw et al. 1974; DeLeeuw and Struyk 1975; Ingram, Kain and Ginn 1972; and Muth 1961) empirical urban housing market analysts have concentrated on metropolitan areas taken as a whole, rather than on the intrametropolitan variability of housing market conditions. This paper attempts to begin filling this gap by using a model of housing supply in geographic zones comprising a metropolitan area to examine the partial equilibrium (supply side only) impact of several policies. The public actions to be examined include changes in zoning of two types, provision of sewers, a policy of eminent domain to "produce" vacant land, and a subsidy to new construction. The first section of the paper briefly describes the housing supply model. The next section describes the simulation methodology used to trace out the implications of the model with respect to these policies. The third section of the paper presents the simulation results and their implications.

1. MODEL OF HOUSING SUPPLY IN A MULTIZONED METROPOLITAN AREA

A set of seven equations is used to model decade changes in the number of housing units by structure type and mode of supply for a set of geographically defined zones comprising a metropolitan area. The parameters of the model have been estimated using data on the period 1960 to 1970 for eighty-nine zones in the Boston metropolitan area (seventy-five cities and towns surrounding Boston and fourteen districts comprising the city of Boston). The equation estimates are presented in Table 1. What the model assumes and the estimates imply is briefly described below.[1]

The basic measure of housing quantity is the number of housing units. These units are differentiated according to structure type: single family units, multifamily units (in structures with two to four units), and apartments (in five or more unit structures). Two modes of supply changes are treated separately: new construction and alterations in or withdrawal of existing units (conversion-retirement). The housing market is seen as equilibrating at the jurisdictional (zonal) level through adjustments in zonal average housing prices and vacancy rates. In addition to these endogenous variables, the basic determinants of supply changes are local input market conditions and constraints on market activity (such as zoning).

In each zone, the percentage change in the housing stock through new construction is a function of beginning-of-decade vacant and residential land use, price change, zoning, contemporaneous business land use changes, and vacancy rate change. This new construction is divided among the structure types as a function of the price of land, which is proxied by the fraction of land in the zone that is vacant. The structure type shares of new construction are also affected by the availability of sewers and by various zoning constraints. Underlying both the total and structure type shares relationships for new construction is a model of land speculation which suggests that fraction of land vacant is a good indicator of land price and price elasticity of land supply to residential use.

Changes in the existing stock are modelled separately for each structure type, but with a similar general form. For each dependent variable structure type, likely "origin" stocks are identified. These are generally the old (built more then twenty years before) and deteriorating housing units of that structure type, and the old stock of the next less dense structure type. The probability of conversion-retirement of that origin stock and the direction of its effect on the dependent variable stock is modelled as a function of market signal variables and zoning restrictions (where applicable) . In addition, the likelihood of demolition of old single family and old multifamily units to make room for new construction is taken to be a function of the availability of vacant land in the zone.

It should be noted that using zones as the observation points involves the assumption that the basic parameters of the model are the same across locations. However, while the specification of the model is the same across zones, the interaction of estimated parameters with location-specific exogenous variables allows market responses to vary in systematic ways over space. An example of this is the price elasticity of new construction housing supply, which is calculated as the product of an estimated (constant) parameter and the local ratio of vacant to residential acres. Similarly, while the effect of a given amount of price change on the probability of conversion-retirement of old single family (multifamily, apartment) units is assumed (and estimated) to be constant, the actual frequency and outcome of such activity in a zone depends on the existing local stock of old singles (multis, apartments), as well as the zonal price change. These two examples point up the most important aspect of metropolitan location from the supplier's point of view: the spatial variation in price and availability of inputs. Since capital and labor prices are generally uniform within a metropolitan area, the variable factors are land for new construction, and starting stock for conversion-retirement.

When the parameters of these relationships were econometrically estimated, the results were in general in line with a priori expectations. For new construction, price increases and vacancy rate decreases encouraged increases in new housing unit production. The spatial pattern of price responsiveness was of particular interest. As predicted, the price elasticity of supply through new construction was higher in the less developed suburbs than in the denser central region of the metropolitan area. This variation is attributed to the more price-elastic supply of land and lower land price in the suburbs, in conjunction with a housing production function characterized by a less than unitary elasticity of substitution between land and the other factor inputs. Minimum lot size zoning restrictions were found to reduce new construction, as were contemporaneous increases in nonresidential land use.

The new units were predominantly single family units in some zones and apartment units in others. The major predictor of structure type is the fraction of land in the zone that was vacant. This relationship presumably reflects producer substitution away from the factor land where it is scarcer and hence more expensive. Zoning regulations that specifically or implicitly rule out certain structure types were also found to influence the structure type composition of new construction. In addition, the lack of availability of sewers proved to be a constraint on apartment construction.

The net changes in housing stock produced by conversion-retirement decisions of owners depended most importantly on the number, age, and structure type composition of the existing stock. Also, new construction was found to be associated with greater demolitions of old units in zones with little vacant land. In addition, the endogenous price and vacancy rate changes influenced the conversion-retirement rates. On average, the effects of price and vacancy changes were found to be what would be expected for suppliers of a commodity: conversion-retirement activity augmented the number of housing units of each structure type more (or reduced them less) where prices rose more and vacancy rates fell more, that is, where housing markets were tighter.

This set of estimated relationships provides the framework in which various policy changes can be simulated.

2. METHODOLOGY

The objective of the proposed simulations is to examine the partial equilibrium impacts of changes in variables that affect housing supply. The local public actions to be examined include changes in zoning of two types, provision of sewers, a policy of eminent domain to "produce" vacant land, and a subsidy to new construction. All of these variables except the last two explicitly enter one or more of the six estimated supply equations.

A partial equilibrium analysis of a supply shift treats price and vacancy rate changes as given, focusing only on the direct impact on supply implied by the estimated coefficient on the variable causing the supply shift. The difference between a partial and full equilibrium simulation is made clearer with reference to a simple supply and demand diagram. If the equations estimated were for quantities supplied and demanded, Figure 1 would exactly represent the analysis; in fact, since the actual equations are for percentage changes and include endogenous vacancies as a discrepancy between supply and demand, the diagram provides only a useful analogy to the actual situation. Figure 1 shows quantity demanded and quantity supplied as (linear) functions of price (curves D and S, respectively). They are drawn with the slope signs usually assumed by economists, that is, upward-sloping supply, and downward-sloping demand. Since this is a two-dimensional diagram, it shows only one of the many variables on which quantity supplied is dependent--price--and implicitly takes as given the values of the other variables. A change in any other variable of which quantity supplied is a function will cause a vertical shift in the supply curve as drawn in quantity-price space. For example, if the multiple regression equation estimates a negative coefficient on minimum lot size zoning in the supply equation, this means that, given the values of the other variables, higher levels of minimum lot size zoning are associated with smaller amounts of housing supply. In quantity-price space (Figure 1), this means that if minimum lot size zoning increases, the supply curve S shifts down to S': at a given price, fewer housing units are supplied.

A partial equilibrium analysis treats price (and all the other independent variables) as given; that is, in looking at the effects of a shift in the supply curve such as that from S to S', it looks at the change in quantity supplied, assuming that the price is still what it was before the shift. In terms of Figure 1, if (P_0, Q_0) were the original equilibrium values of price and quantity, respectively, then a partial equilibrium analysis of a change in zoning policy that causes S to shift to S' records P_0 and Q' as the outcomes. Q' is the point on the new supply curve S' corresponding

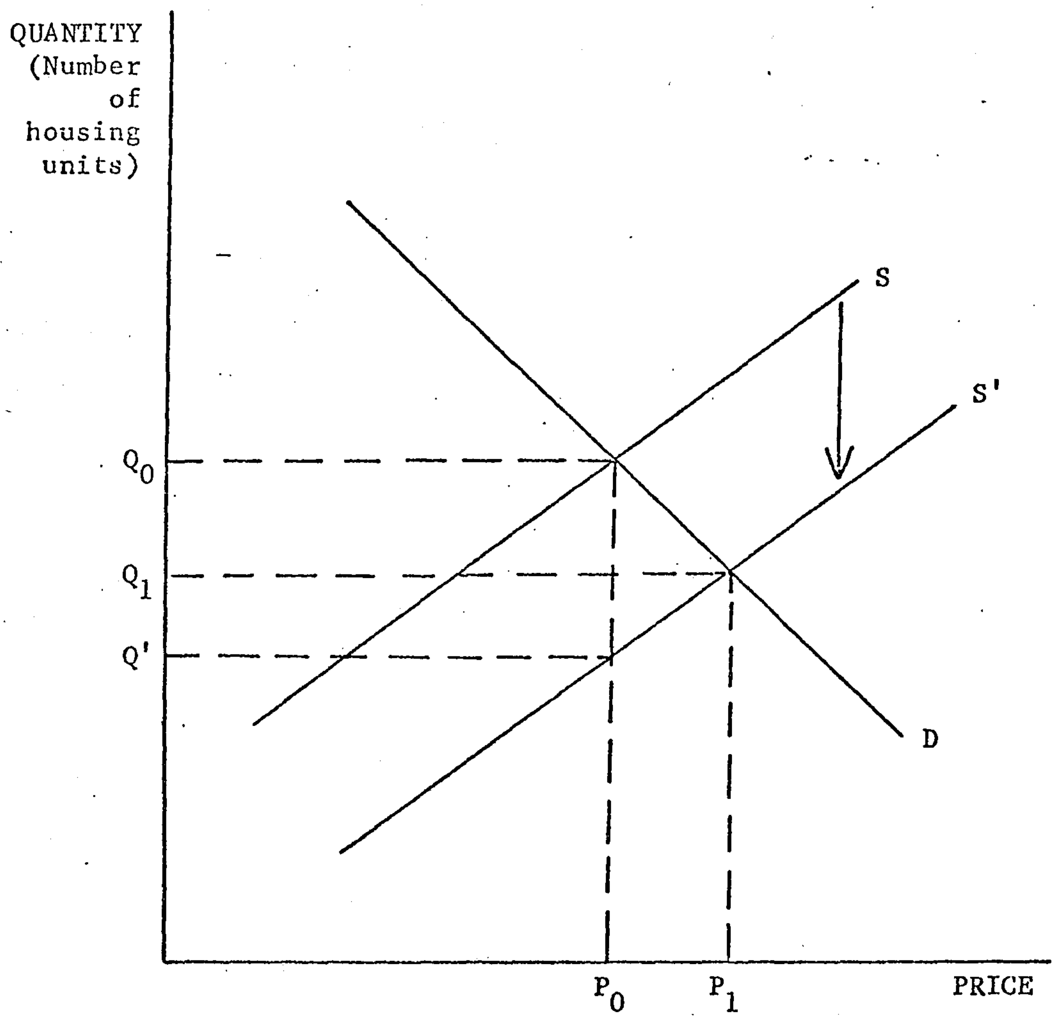

Figure 1. Shift in supply curve.

to the initial price, P_0. The change in price resulting from the shift is assumed to be zero, the change in quantity is correspondingly found to be $(Q'-Q_0)$; that is, a partial equilibrium analysis implicitly ignores the demand curve.

A full equilibrium analysis, on the other hand, requires knowledge of the supply and the demand curves, even if the policy being analyzed shifts only the supply curve. In Figure 1, the original equilibrium point is (P_0, Q_0), given demand curve D and supply curve S. If something shifts the supply curve to S', the new equilibrium is (P_1,Q_1), the point of intersection of S' and D. The equilibrium price and quantity have both changed, since the shift in S implies movement along D to the new equilibrium.

If the demand curve is not vertical, it is clear that the partial and full equilibrium results of a shift in the supply curve do not coincide. The correct result is the full equilibrium result which represents both sides of the market. But the partial analysis can still be quite useful, for if the supply and demand curves satisfy some simple conditions of "good behavior," the partial analysis correctly indicates the direction of the change in equilibrium quantity resulting from the shift. In general, the direction of quantity change derived from the partial analysis coincides with the sign of the (correct) full equilibrium result in all cases except the case of a horizontal demand curve (when demand is totally inelastic, a shift in the supply curve must have a zero effect on quantity), and cases where the supply and demand slopes are of the same sign and supply is steeper than demand.

In the example shown in Figure 1, the partial analysis overstates the amount of quantity change resulting from the shift: $|Q'-Q_0| > |Q_1-Q_0|$.

The heuristic explanation for the overstatement is that the partial analysis fails to take account of the fact that as quantity falls, the price demanders are willing to pay for the remaining units rises (this is what the negative slope of the demand curve means) and suppliers respond to this higher price with more units (because the supply curve has positive slope). If the demand and supply curves have the same signs but supply is flatter than demand, then the partial analysis understates the full quantity change resulting from the shift. If the demand curve is vertical or the supply curve horizontal, the partial analysis result exactly coincides with the quantity change calculated from the full equilibrium system.

The point of this discussion is to suggest the value (and also limitations) of the partial analysis approach. Given some estimates of the parameters of housing supply equations, if information on the demand curve is lacking, the partial analysis makes it possible to derive some qualitative results about the effects on market quantities of shocks to the supply side of the market, under the assumption that the system is "well-behaved" as discussed above.

The methodology used to simulate shocks to the supply side of the market is quite straightforward. Each policy or shock can take the form of a change in one or more variables in the supply equations. Minimum lot size zoning affects total new construction and the shares of new construction that are of each structure type. It also affects the magnitude of single family conversion-retirement activity, and the conversion of old single units to multifamily units. Zoning which bans the construction of apartments affects the share of new construction that is apartment units (and also affects, since it is residual, the share that is multifamily).

The provision of sewers, while it has no modelled impact on total new construction, does affect the shares of new construction that are of each structure type.

Neither eminent domain nor a subsidy to new construction has been included in the supply equations as an explicit variable, but both can be approximated by changes in variables that are explicitly included. If the government uses the power of eminent domain to take land from its current use and make it available to private developers in the way any other vacant land would be available, then the effect of such a policy can be approximated in the model by changing the initial value of vacant acres in a zone, as well as the initial value of acres in other uses from which the land is taken. (It has been argued that this is also the form that much urban renewal has taken.) Similarly, if a subsidy to residential new construction is perceived by builders as lowering the costs of production, its impacts can be modelled by examining the outcome of a price change 10% higher (say) for new construction than the market actually generates.

The simulations consist of making such changes in the variables, applying the estimated coefficients to them, and thereby generating estimates of the resulting changes in 1970 housing supplies by zone. These changes are aggregated and summarized in various ways, and compared with the unshocked 1970 fitted values produced by the equations. This discussion should make clear one characteristic of the supply-side-only simulations: changes are seen only in zones directly affected by the shock. For example, one of the simulations looks at what would happen, according to the estimated equations, if there were no minimum lot size zoning in the whole metropolitan area. This change affects only those zones in the sample that actually have some degree of minimum lot size zoning. This contrasts with a full equilibrium simulation in which the cross-elasticities of zone demand could be taken into account, and therefore a direct change in supply in one zone that affects the price there may affect the demands, hence prices, hence supplies in all other zones.

The outcomes of the simulations are changes in housing supplies by structure type and mode of supply for the eighty-nine zones in the metropolitan area sample, as compared with the "control" fitted values. Since it is difficult to examine and digest eighty-nine individual changes, the results are also summarized for three broad geographic regions in the metropolitan area. The three areas are roughly concentric rings of municipalities that are called "central," "inner ring," and "outer ring," and are displayed on a Boston metropolitan area map in Figure 2.

Before moving into discussion of the specific policies and their simulated outcomes, one final general point should be made. A supply-side-only simulation is appropriate only for policies which do not directly affect demand, or at least which have their major impact on supply. If a policy shifts the supply curve as discussed, but also causes the demand curve to shift, it can no longer be argued a priori that a partial analysis correctly indicates the direction of market responsiveness. Further information on the magnitude and direction of movement of the demand curve is needed to predict the direction of the final equilibrium outcome. For this reason, the policies to be simulated in this chapter are carefully chosen to have their major impacts on supply. Programs like public housing, which act partly through the supply side of the market, also change housing demand by those households which qualify for the subsidy implicit in receiving their services. These

Figure 2

Boston metropolitan summary regions.

programs, as well as those which act only on demand, can therefore be simulated only in a full equilibrium context.

3. SIMULATION RESULTS

Apartments Banned Nowhere

The first policy simulation examines the impact of removing all zoning that prohibits the construction of apartment-type housing units. The hypothetical question being asked is how different the 1970 housing stocks would have looked if as of 1960 no such zoning had been in force in any of the cities and towns in the metropolitan area.

A large difference cannot be expected for two reasons. First, apartments-banned zoning enters the model only through the equation for the share of total new construction that is apartments. Therefore, the total number of housing units will not be affected at all by the change. Second, only nine zones out of the eighty-nine in the metropolitan area actually use such zoning restrictions. These zones account for about 2.5% of the 1960 metropolitan housing stock and roughly 14% of the metropolitan land area.

The simulation shows an aggregate increase of roughly 300 apartment units (and corresponding decrease of 300 multifamily units) constructed between 1960 and 1970 in the nine zones. This amounts to an increase of about six-tenths of 1% in new apartment units constructed in the metropolitan area during the decade. This increase in new construction of apartments leads to the result that the 1970 metropolitan stock of apartment units is .15% greater. The share of the 1970 stock that is apartment units is 1.3 points higher in the affected group of nine zones.

This result can be broken down into the effects on the three geographic groups of zones: the central region includes no zones with apartment-banned zoning and hence shows no changes; the inner ring contains one zone that prohibits apartments, with elimination of that ban predicted to increase the 1970 stock of apartment units in the inner ring by .3%; the outer ring has eight affected zones which would show .8% more 1970 apartment units in the absence of zoning. These numbers all sound very small--and they are--but for perspective on these and the later simulation figures, it should be recalled that all new construction and conversion supply for all structure types during the whole decade account for about 14% of the 1970 metropolitan area stock; that is, 86% of the 1970 housing stock is units carried forward (changed or unchanged) from 1960.

This simulation makes clear that according to the model, apartments-banned zoning is indeed a binding constraint on the structure type of new construction, as it is intended to be by those who enact it. In its absence, the towns that employ such zoning would experience at least a small amount of construction of units in five or more unit structures.

For most of the simulations to follow, the outcomes will be compared only with the values predicted by the equations in the absence of the policy change or shock (the "fitted" or "control" values). However, because of the nature of the relationship specified in the model for apartments-banned zoning, it seems appropriate in this particular case to make another comparison as well. The model assumes that the effect of apartments-banned zoning is binding: in those towns in which apartments are banned, the equation for the share of new construction that is apartment units is multiplied through by a zero value of the variable "A". This assumption was tested in the sense that it fits the actual data better than alternative specifications. Given this specification, however, lifting the ban must produce some modelled effect. To see if the predicted effect is sizable on some less contaminated scale, it seems worthwhile to compare the simulated outcome with the actual observed outcome. In the nine zones using apartments-banned zoning, a total of one hundred apartment units were actually built between 1960 and 1970, presumably through the approval of zoning variances or the like. Thus the simulation predicts a value that implies a tripling in apartment new construction if the ban were lifted. The policy change would seem to induce a noticeable change in outcomes even measured on this smaller scale.

No Minimum Lot Size Zoning

The second policy simulation looks at the effects of removing all zoning requiring lot sizes greater than 25,000 square feet. Such zoning was actually used in forty-five towns, with the fraction of town area restricted ranging from 12.5% to 100%. The forty-five zones accounted for 24% of the metropolitan housing stock in 1960, and 69% of the land area.

Minimum lot size zoning enters the model in several ways. The fraction of land both vacant and not subject to minimum lot size zoning has a positive effect on total new construction. In addition, the fraction of land subject to minimum lot size zoning has a one-for-one effect on the fraction of new construction that is single family. Land not subject to minimum lot size zoning is divided among new construction structure types on the basis of vacant land scarcity. Finally, minimum lot size zoning affects the conversion-retirement decisions of owners of single family units, and in particular, affects the conversion of old single family units into multifamily units.

The simulation outcome shows an increase of 10,000 units in total new construction in all affected zones, amounting to 20% more new units over the affected area, or close to 8% more new construction for the metropolitan area as a whole. Of these new units, the fraction single family falls and the fraction apartment rises when no zoning effectively limits such denser units. However, since the total new construction rises everywhere, the number of new single family units rises in some zones and falls in others, whereas the number of new multifamily and apartment units rises in all affected zones. For the metropolitan area as a whole, there are 2,200 more new single family units, 1,700 more new multifamily units and 6,100 additional new apartment units.

The conversion-retirement equations show the loss of fewer old single family units than in the "control" situation, since the coefficient on fraction of land subject to minimum lot size zoning is negative in the single-family conversion-retirement equation. With more new construction, demolition of singles and multis will be slightly higher; but this is not a strong effect, since most of the towns with minimum lot size zoning have large quantities of vacant land, and the demolition of old singles and multis to make room for new construction is inversely proportional to vacant acreage. Minimum lot size zoning enters the multifamily conversion-retirement equation multiplicatively with old single family units. Thus the effect of zoning on the 1970 multifamily stock through conversion of singles depends on the values of the other multiplicative variables: old single family stock, and the direction of endogenous price change and vacancy rate change. In some municipalities, the elimination of zoning reduces the number of multifamily units resulting from conversion, in others, it increases. For the metropolitan area as a whole, 2,300 more 1960 single family units are carried forward to 1970 and 1,700 more multifamily units are created from singles. This suggests that minimum lot size zoning causes the demolition of some single family units that in its absence are put to other uses. No changes occur in the conversion-retirement activities affecting apartments.

As a result of these changes in new construction and conversion-retirement activity, the 1970 stocks by structure type in each zone are changed by the elimination of minimum lot size zoning. For the metropolitan area as a whole, there are 13,000 additional units in 1970, 1.5% more units than in the presence of zoning, which is 5.5% more for those zones actually involved in the change. This increase is made up of 4,500 more single family units, 2,400 additional multifamily units and 6,000 more apartment units. In percentage change terms, the positive effect on apartment units (a 3% increase in 1970 apartment stock) is greatest, as might be expected, since they are the most constrained by the zoning. The fraction of the 1970 stock of the affected zones that is new (built in the preceding decade) is three percentage points higher in the absence of minimum lot size zoning. The fraction single is lower by two percentage points than when lot size minima apply, offset by increases in the shares of 1970 stock which are multifamily (one-tenth of a percentage point) and apartment units (1.9 percentage points).

Looking at the three geographic groups of zones, more detailed effects can be reported. Of the twenty zones in the central region, only one uses a minimum lot size zoning constraint that covers one-fifth of its land; four of the seventeen inner ring jurisdictions impose minimum lot sizes, each of which covers less than a third of the town area; and only twelve out of fifty-two outer ring towns do not use some minimum lot size restrictions. Thus the effect on the central region is understandably slight, an increase of 115 units in total, made up of a decrease of 425 single units with offsetting increases of 45 to 495 in multifamily and apartment stock, respectively. The inner ring shows a .25% increase in total housing units, consisting of a decrease of 63 single family units and increases of 214 and 477 in multifamily and apartment stock. The outer ring, where vacant land is much more plentiful and hence new construction more responsive to loosening of zoning restrictions, actually shows an increase in all three structure type stocks, since the negative effect of lifting the zoning constraint on the share of new construction that is single family is more than offset by the postitive effect on total new construction. The percentage change in apartment stock is again the greatest; the simulation shows a 23% increase in 1970 apartment stock in the outer ring, an increase of 5,200 units on a base of 28,000.

These results suggest that elimination of minimum lot size zoning constraints is likely to have a non-negligible impact on metropolitan area housing stocks, both by increasing the total units and by reducing the share of the total that is single family units.

No Minimum Lot Size Zoning and No Apartments-Banned Zoning

The third simulation examines the combined impact of the two shocks just examined individually, the removal of apartments-banned zoning and the removal of lot size minima in excess of 25,000 square feet. These are the only types of zoning restrictions explicitly included in the housing supply model. To the degree that other forms of residential zoning are used by municipalities in conjunction with these two types, and such use is systematically related to the two observed types, this simulation represents their elimination as well. The change affects the forty-five zones that impose minimum lot size zoning, which includes the nine zones employing apartment bans.

Because apartments-banned zoning is modelled to affect only the multifamily and apartment structure type shares of new construction, and not the total number of units, the results for new construction of singles, conversion-retirement in general, and total units are the same as for the minimum lots size elimination alone. However, the structure type shares reflect the combined effect of the two zoning types; the effect is not simply additive because the two variables enter the new construction apartment share equation multiplicatively. The simulation shows an increase of 7,600 in new construction of apartment units in the metropolitan area, which is 1,500 more than for eliminating minimum lot size zoning alone, and compares with the 300 unit increase that resulted from dropping the apartment ban alone. Thus the combined effect is substantially larger than the sum of the two separate effects; not a surprising result when one considers that in the absence of apartments-banned zoning, apartment construction is inhibited in those areas of town covered by minimum lot size zoning, and even when lot size minima are eliminated, apartments will not be built in towns in which they are prohibited. By eliminating both forms of zoning, the 1970 metropolitan stock of apartment units is increased by 4%, which is a 29% increase in apartment units in those towns actually employing the zoning restrictions. This compares with 2.5% increases in 1970 single family and multifamily units in the affected zones. The shift in shares of 1970 stock in the affected zones which are of each structure type is greater than for the simulation of elimination of minimum lot size zoning alone. This time we see an increase of 2.5 percentage points in the apartment share, and decreases in both multifamily and single family shares of .5 and 2.0 percentage points, respectively.

Sewers Available Everywhere

The fourth simulation examines the impact of sewer lines being accessible in all parts of all the metropolitan municipalities. There are actually sixty cities and towns in which less than 100% of the population is served by sewers, with twenty-two towns having no sewers at all. Sewer availability is modelled as affecting only the shares of new construction that are of each structure type, and not as a constraint on total new construction or on conversion-retirement activities.

The simulation shows a decrease of 6,100 in new single family units with offsetting increases of 300 and 5,800 in construction of new multifamily and apartment units, respectively. This amounts to a 9% decrease in single family construction, and 3% and 12% increases in multifamily and apartment unit construction, respectively. For the zones actually affected by the simulated change, these responses cause non-negligible changes in the 1970 housing stocks by structure type. The single family stock is reduced by 2% and the apartment stock increased by 18% on the whole for the group of zones with incomplete sewering.

The changes can also be examined for the three geographic groups of zones. The central area is unchanged, since all zones within it have complete sewering. The inner ring contains eight municipalities with incomplete sewer availability, only two of them (at 40 and 67%) less than 80% served by sewers. None of the outer ring zones has complete coverage by sewers. The inner ring shows a decrease of 750 new single family units, offset almost entirely by new apartment units (the small difference being multifamily units), under the hypothetical situation of full sewer availability. The outer ring, with much less sewering to start with, shows greater simulated responses to the change. The 1970 single family stock would be smaller by 5,350 units and the apartment stock larger by 5,050 units. This latter figure is a 22% increase in the number of apartment units available in 1970 in the outer ring.

The equations as estimated and used for simulation suggest that infrastructure such as sewer lines can have an important (indirect) effect on the type of new construction being carried out, along with such explicit structure type controls as zoning.

Eminent Domain on Nonresidential Land

The next policy makes more vacant land available in zones where it is scarce. The simulation examines the impact on housing supplies of there being at least 5% vacant land in every zone in the metropolitan area as of the beginning of the decade. In those zones that did not actually have that much vacant land, the government hypothetically "produces" it by using its power of eminent domain to claim land not currently in residential use; for example, land used for outdoor recreation (parks), or commercial and industrial uses. It is assumed that after the government clears it, the new vacant land appears in the land market just as any other vacant land would, some of it being bought and used by housing producers.

This policy affects only the fifteen zones in which less than one-twentieth of the area was vacant at the beginning of the decade. These fifteen zones contain 5% of the metropolitan land area, and 31% of the total 1960 housing stocks. They have a 1970 gross residential density (housing units per total acre of land) of 8.6, as compared with 1.1 for the rest of the metropolitan area. All but one of the affected zones are in the central geographic region; in fact, nine are within the city of Boston. Taken as a group, the affected zones have almost 3% vacant land, or roughly 900 acres vacant. Another 600 acres are taken from nonresidential uses and added to the vacant category in this simulation.

The effects of this change come through all of the model's equations except for the conversion-retirement of apartment units, since vacant acres do not enter that equation. New construction increases in all the affected zones as a result of the increase in available vacant land. The 2,600 additional new units represent a 2% increase in new construction for the metropolitan area as a whole, and 10% increase for the fifteen zones actually involved. The shares of new construction that are of each structure type are also affected: with more vacant land, the fraction apartments falls and the fraction singles rises. With the total rising as well, new construction of single family units increases in all affected zones, new multifamily and apartment construction rise in some zones and fall in others. The net effect is an increase of 6,600 and 100 in new single family and multifamily units, respectively, and a decrease of 4,100 in new apartment units. For the metropolitan area as a whole, this is a 9% increase in new singles, and an 8% decline in new apartments.

Conversion-retirement activity is also affected by the creation of vacant land, through the term reflecting demolition due to new construction. The estimated relationship assumes that demolition of old singles and old multifamily units is proportional to total new construction and inversely related to the number of vacant acres. Thus the change due to the eminent domain policy has two parts: an increase in demolitions as new construction increases and a decrease in demolitions as vacant land increases. The net result for both single family and multifamily units is positive, that is, fewer demolitions occur. A total of 1,700 more units survive the decade than in the control situation. The fact that the outcome is positive provides reassurance about the specified relationship. It seems eminently reasonable that an increase in new construction induced by an increase in vacant land should not cause the demolition of existing units as a result. The positive conversion-retirement outcome implies that the new vacant land not only absorbs the additional new construction it educes, but also takes some of the new construction that would otherwise have occurred on demolition sites.

Combining the new construction and conversion-retirement changes yields a net increase in housing units of 4,300 units, a .5% increase in the metropolitan area of 1970 housing stock. This is a 1.5% increase for those zones actually involved in the change. The stock of single family units is 7,300 units greater, the stock of multifamily units rises by 1,100, and the apartment units stock declines by 4,100, as compared with the situation without eminent domain. In the group of zones actually affected, the increase is 22% in the 1970 stock of singles, and the apartment decline represents close to 4% of the 1970 stock. The eminent domain policy increases the fraction of the 1970 stock in the affected zones that is new (built in the preceding decade) by eight-tenths of a percentage point. The fraction of the 1970 stock in the affected group of zones that is single family units is 2.5 percentage points higher when the eminent domain policy is employed than in the control situation, offset by decreases in the multifamily and apartment share.

There is a "notch" in the structure type shares of new construction equations at 5% land vacant: for percentage vacant less than five, the dummy variable V1 is "on"; for 5% to 9.99999%, the dummy variable V2 is equal to one. There is a similar notch at each category break-point. The results just reported reflect the fact that the eminent domain policy simulated pushes all the zones in the V1 category just over the line into the V2 category, and thereby affects the predicted structure types shares of all new construction occurring in the zones (not just the policy-induced incremental new construction). For comparative purposes, it is interesting to take out this notch effect and act as if the line were not crossed; in essence, to run the same simulation but bringing the percentage vacant land up to 4.99999 rather than 5. The effects on total new construction and conversion and hence total 1970 stock are identical to the previous ones, but the structure type outcomes differ fairly substantially because the estimated coefficients on V1 and V2, representing the new construction structure type fractions for zones in each category, differ by more than .2 in both equations (2) and (3). In this case we find that new construction of all structure types increases relative to the control situation, in contrast to the previous result that the apartment new construction declined relative to the control. Similarly, for the 1970 stocks, each structure type is greater than in the control; for the affected zones taken as a group, the 1970 single family stock is 3% greater, there is 1% more multifamily stock, and apartment units have increased by almost 2%, relative to the control situation. Looking at the structure type shares of 1970 stock for the fifteen zones, single family units gain two-tenths of a percentage point and multifamily units comprise one quarter of a percentage point less of the total stock compared to the control. This compares with the 2.5 percentage point gain of singles just cited when the notch has its effect.

This simulation requires some interpretation for two reasons. First of all, it is fairly clear that the occurrence simulated is not politically feasible nor probably even desirable on any policy grounds. Local governments are not likely to want to take land from private use, then clear it, and offer it for private use.[2] The point of the simulation is not to recommend the specific policy, but rather to illuminate the workings of the housing market by examining the predicted responses to a particular sort of change in the environment. Secondly, the exact predictions of the model must be treated with caution because the vacant land variable is used in several different ways in the model specification, not all of which have straightforward extensions to this policy. Specifically, in the total new construction equation, vacant land enters the price elasticity of new housing supply expression divided by residential acres to represent a rather complicated relationship involving the price elasticity of the supply of land to housing producers. Also, categories of fraction-land-vacant representing the price of land are important determinants of the structure type shares of new construction. Since the workings of the land market are not explicitly modelled, it cannot be assumed that the effect of the eminent domain policy on vacant acreage has the same impact on the housing market as would a "natural" (land market outcome) change in vacant acreage.[3] Thus the full effect of the policy on the price and supply elasticity of land and on the supply of housing may not be adequately captured by the change in vacant acreage as it enters the specified expressions. However, the result probably does reflect the general direction and magnitude of the policy impact.

Given those two background comments, the implications of the simulation results can be summarized. It appears, not surprisingly, that vacant land plays an important role in the workings of the housing market. What seems like a small change in vacant land available in the metropolitan area (600 acres relative to 278,000 total vacant acres), when appropriately located, can slightly but noticeably affect the location and magnitude of housing unit supplies. The larger housing stock that the greater vacant land can support comes both from new construction and greater preservation of old units.

Subsidy to New Construction

The final policy simulation carried out using the supply side equations alone displays the effects of a subsidy to builders of new housing. The subsidy takes the form of a 10% refund of the total costs of the finished unit, and hence is modelled as a value for the price change variable in the new construction equation that raises the 1970 price perceived by builders to 10% above the actual 1970 housing price in the zone; that is, the variable $\Delta PRICE/PRICE_{60}$ is increased by (.1) ($PRICE_{70}/PRICE_{60}$) as it enters the new construction equation. This policy is applied to all eighty-nine zones in the metropolitan area. The simulation is at the simplest a demonstration of the price elasticity of new supply as it varies over the zones, but with an added component. Because new construction may cause demolition of existing units where vacant land is scarce, the increase in new units is partially offset by losses of existing old units. These combined effects are the outcome of the simulation.

New construction increases in all zones when the subsidy is applied. The increase ranges from 29% to .1%, depending on the zone's price elasticity of new supply,[4] and is 6% for the metropolitan area as a whole. The responses are 2%, 3%, and 9% new construction increments for the three geographic groups of zones, moving from central to outer ring.

While the shares of new construction of each structure type remain the same in each zone, the same is not true for the metropolitan area as a whole, because the weights change. The new construction increment is greater in towns with more vacant land where a larger share of new construction is single family units. Therefore, the subsidy results in a greater percentage increase in new single family units (about 8%) than new multifamily (5%) or apartment units (3%) for the metropolitan area as a whole.

The conversion-retirement response is quite small, since it comes only from the demolitions of old units brought about to make room for the additional new construction. Nine old single family units and sixteen old multis are demolished on account of the subsidy.

Combining the two elements, the net effect is an increase of 1.4% in the number of single family units in the metropolitan area in 1970, and increases of .2% and .9% in the 1970 stocks of multifamily and apartment units, respectively, yielding an overall metropolitan 1970 stock increase of .8% (with a range across zones from 8.2% to .02%). The increases are largest in the outer ring area where there is more vacant land and therefore greater price responsiveness. Moving from outer ring to central, the percentage changes in 1970 housing stock due to the new construction subsidy are 2.0, .4, and .2, respectively.

The policy also changes the composition of the stock. The share of the 1970 metropolitan area housing stock that is new (that is, built during the preceding decade) is increased by seven-tenths of a percentage point. The single family structure type accounts for .2 percentage points more of the total 1970 stock of units, mostly at the expense of the multifamily share.

One can conclude from this excercise that a new construction subsidy can indeed increase the amount of new construction, and not just at the expense of conversion supply; that is, the subsidy increases the total stock of housing units when the test of demand is ignored. However, perhaps of more interest, there is a wide variability across zones in the supply responsiveness to such a program that largely reflects the wide variation in land supply and price. Any such policy would encourage suburban growth much more than growth in the denser central areas. (Recall the figures cited directly above that showed the percentage change in total 1970 housing stock in the outer ring to be ten times that of the central region.) This finding is not unrelated to Richard Muth's conclusion that the implicit subsidies to home ownership contained in United States tax laws are partly responsible for the larger growth of the urban fringes relative to the center (1969), although a subsidy to home ownership is certainly not directly a subsidy to all new construction. The policy of a new construction subsidy also encourages single family construction more than other structure types because single family units are the appropriate type in those areas most responsive to the subsidy.

4. CONCLUSION

The set of simulation results presented above provides a measure of the size and variation of the coefficients estimated in the supply equations on variables subject to potential policy control. The simulations of changes in zoning and sewer availability displayed the degree to which zoning regulations and sewer availability act as binding constraints on housing production, constraining either the quantity produced or the producers' cost-minimizing structure type choice, both for new construction and for owners engaging in conversion-retirement. The eminent domain policy brought all zones up to 5% vacant land by condemning some nonresidential uses. The fairly substantial impact this had on decade housing production in the affected zones made clear how serious a constraint on housing production is the scarcity of vacant land in the most densely developed zones. Results of the simulated new construction subsidy displayed how much the price elasticity of new housing supply varies over the metropolitan area.

Table 1

Estimated Supply Equations
(see appendix for definition of variables)

NEW CONSTRUCTION EQUATION

Two stage least squares treating price and vacancy variables as endogenous.

(Asymptotic standard errors in parentheses below estimated coefficients)

$$\frac{\text{NEW TOTAL}}{\text{TOTAL}_{60}} = \underset{(.0278)}{.120} + \underset{(.0113)}{.0714} \frac{\text{VACANT ACRES 60}}{\text{RESIDENTIAL ACRES}_{60}} \cdot \frac{\Delta\text{PRICE}}{\text{PRICE}_{60}}$$

$$- \underset{(.120)}{.237} \frac{\Delta\text{MANUF ACRES}}{\text{RESIDENTIAL ACRES}_{60}} + \underset{(.104)}{.262} \text{ OPEN}$$

$$- \underset{(1.45)}{2.80} \frac{\Delta\text{VACANT}}{\text{TOTAL}_{60}} + e. \qquad (1)$$

$R^2 = .4335$

Standard error of the regression = .132

NEW CONSTRUCTION STRUCTURE TYPE SHARES EQUATIONS

Ordinary least squares

(standard errors in parentheses below estimated coefficients)

$$\frac{\text{NEW SINGLE}}{\text{NEW TOTAL}} = \underset{(.0425)}{.958} \text{ PZ} + \text{UZ} \cdot \Big[- \underset{(.00111)}{.00278} \text{ SEWER} + \underset{(.119)}{.392} \text{ V1}$$

$$+ \underset{(.123)}{.618} \text{ V2} + \underset{(.109)}{.700} \text{ V3} + \underset{(.110)}{.799} \text{ V4} + \underset{(.0854)}{.828} \text{ V5}$$

$$+ \underset{(.0881)}{.907} \text{ V6} + \underset{(.0879)}{.768} \text{ V7} \Big] + e. \qquad (2)$$

$R^2 = .7921$

Standard error of the regression = .157

Table 1-Continued.

$$\frac{\text{NEW APART}}{\text{NEW TOTAL}} = A \cdot UZ \cdot \Big[\underset{(.00105)}{.00276}\ \text{SEWER} + \underset{(.112)}{.518}\ V1 + \underset{(.117)}{.298}\ V2$$

$$+ \underset{(.103)}{.145}\ V3 + \underset{(.104)}{.130}\ V4 + \underset{(.0803)}{.0936}\ V5 + \underset{(.0815)}{.0644}\ V6$$

$$+ \underset{(.0779)}{.192}\ V7 \Big] + e. \qquad (3)$$

$R^2 = .7770$

Standard error of the regression = .149

$$\frac{\text{NEW MULTI}}{\text{NEW TOTAL}} = 1 - \widehat{\frac{\text{NEW APART}}{\text{NEW TOTAL}}} - \widehat{\frac{\text{NEW SINGLE}}{\text{NEW TOTAL}}}, \qquad (4)$$

where the '^' indicates the use of the fitted value. This equation is not estimated; it defines the estimated multifamily share of new construction as the difference between all new construction and the estimated single family and apartment shares.

CONVERSION-RETIREMENT EQUATIONS

Two stage least squares treating price and vacancy variables and NEW TIGHT as endogenous.

(Asymptotic standard errors in parentheses below estimated coefficients)

$$\text{CONV SINGLE} = \underset{(67.3)}{34.2} + \text{OLD SINGLE}_{60} \bullet \Big[\underset{(.0563)}{-.217} + \underset{(.0955)}{.191}\ \frac{\Delta\text{PRICE}}{\text{PRICE}_{60}}$$

$$+ \underset{(1.52)}{3.75}\ \frac{\Delta\text{VACANT}}{\text{TOTAL}_{60}} - \underset{(.0840)}{.0686}\ PZ - \underset{(.188)}{1.18}\ \frac{\text{DETER60}}{\text{TOTAL}_{60}} \qquad (5)$$

$$\underset{(.000156)}{-.000271}\ \text{NEW TIGHT} \Big] + e.$$

$R^2 = .7590$

Standard error of the regression = 322.

Table 1--Continued.

$$\text{CONV MULTI} = \underset{(41.4)}{82.4} + \text{OLD MULTI}_{60} \cdot \left[\underset{(.0438)}{.293} - \underset{(.0657)}{.345} \frac{\Delta\text{PRICE}}{\text{PRICE}_{60}} \right.$$

$$- \underset{(.973)}{6.55} \frac{\Delta\text{VACANT}}{\text{TOTAL}_{60}} - \underset{(.0659)}{1.06} \frac{\text{DETER60}}{\text{TOTAL}_{60}}$$

$$\left. - \underset{(.0000812)}{.000166} \text{ NEW TIGHT} \right] + \text{UNZONED OLD SINGLE}_{60} \cdot$$

$$\left[\underset{(.0746)}{.0230} + \underset{(.131)}{.0845} \frac{\Delta\text{PRICE}}{\text{PRICE}_{60}} + \underset{(3.11)}{10.8} \frac{\Delta\text{VACANT}}{\text{TOTAL}_{60}} \right] + e. \qquad (6)$$

$R^2 = .9078$

Standard error of the regression = 267.

$$\text{CONV APART} = \underset{(29.9)}{77.0} + \text{OLD APART}_{60} \cdot \left[- \underset{(.132)}{.508} + \underset{(.171)}{.929} \frac{\Delta\text{PRICE}}{\text{PRICE}_{60}} \right.$$

$$\left. - \underset{(3.16)}{18.0} \frac{\Delta\text{VACANT}}{\text{TOTAL}_{60}} \right] + \text{DETER APART}_{60} \cdot$$

$$\left[\underset{(.551)}{2.34} - \underset{(.719)}{4.33} \frac{\Delta\text{PRICE}}{\text{PRICE}_{60}} + \underset{(7.88)}{29.5} \frac{\Delta\text{VACANT}}{\text{TOTAL}_{60}} \right]$$

$$+ \text{OLD MULTI}_{60} \cdot \left[\underset{(.00948)}{.0431} + \underset{(.719)}{2.60} \frac{\Delta\text{VACANT}}{\text{TOTAL}_{60}} \right] + e. \qquad (7)$$

$R^2 = .9323$

Standard error of the regression = 236.

APPENDIX

Variable Definitions and Data Description

All variables are observed for the sample of eighty-nine zones in the Boston metropolitan area.

Basic Measures of the Housing Stock

$SINGLE_{60}$ ($SINGLE_{70}$) Number of single family housing units in 1960 (1970)

$MULTI_{60}$ ($MULTI_{70}$) Number of multifamily housing units in 1960 (1970) (a multifamily unit is in a structure containing two to four units)

$APART_{60}$ ($APART_{70}$) Number of apartment housing units in 1960 (1970) (an apartment unit is in a structure containing five or more units)

$TOTAL_{60}$ ($TOTAL_{70}$) Total number of housing units in 1960 (1970)

NEW SINGLE Number of 1970 single family housing units built since 1960

NEW MULTI Number of 1970 multifamily housing units built since 1960

NEW APART Number of 1970 apartment housing units built since 1960

NEW TOTAL Total number of 1970 housing units built since 1960

CONV SINGLE 1960 to 1970 decade change in number of single family housing units not due to new construction (CONV SINGLE = $SINGLE_{70}$ - NEW SINGLE - $SINGLE_{60}$)

CONV MULTI 1960 to 1970 decade change in number of multifamily housing units not due to new construction (CONV MULTI = $MULTI_{70}$ - NEW MULTI - $MULTI_{60}$)

CONV APART 1960 to 1970 decade change in number of apartment housing units not due to new construction (CONV APART = APART_{70} - NEW APART - APART_{60})

DETER_{60} Number of housing units deteriorating in 1960

DETER APART_{60} Estimate of the number of 1960 apartment units deteriorating

OLD SINGLE_{60} Estimate of number of 1960 single family units built before 1940

OLD MULTI_{60} Estimate of number of 1960 multifamily units built before 1940

OLD APART_{60} Estimate of number of 1960 apartment units built before 1940

UNZONED OLD SINGLE_{60} Estimate of the number of 1960 single family units built before 1940 which are not subject to minimum lot size zoning restrictions (UNZONED OLD SINGLE = UZ · OLD SINGLE_{60})

NEW TIGHT Number of housing units built between 1960 and 1970 per acre of vacant land initially available (NEW TIGHT = NEW TOTAL/ VACANT ACRES_{60})

VACANT_{60} (VACANT_{70}) Number of housing units vacant for rent or vacant for sale in 1960 (1970)

Local Public Sector

SEWER The percentage of population served by public sewers

PZ Fraction of residential and vacant land zoned for minimum lot sizes greater than 25,000 square feet

UZ Fraction of residential and vacant land not zoned for minimum lot sizes greater than 25,000 square feet (UZ = 1.0 − PZ)

A Dummy variable equal to zero where zoning regulations prohibit apartment structures, equal to one otherwise

Land Use

TOTAL ACRES Acres of land, total area minus acres of open water (not dated because no jurisdictions in the sample changed area over the study decade)

RESIDENTIAL $ACRES_{60}$ Acres of land in residential use

VACANT $ACRES_{60}$ Acres of vacant land (forest land, woodland--not state or national forest, or orchard); agricultural uses and vacant lots (beach--not public or commercial, crops, dairy farm, grassland, greenhouse, livestock, nursery, open land--vacant lots, orchard, pasture, vineyards)

MANUFACTURING $ACRES_{60}$ (MANUFACTURING $ACRES_{70}$) Acres of land devoted to manufacturing

VACP Fraction of land vacant (VACP = VACANT $ACRES_{60}$/TOTAL ACRES)

V1-V7 A set of dummy variables for ranges of value for VACP:

$V1 = 1$ if $VACP < .05$, $= 0$ otherwise

$V2 = 1$ if $.05 \leq VACP < .1$, $= 0$ otherwise

$V3 = 1$ if $.1 \leq VACP < .2$, $= 0$ otherwise

$V4 = 1$ if $.2 \leq VACP < .3$, $= 0$ otherwise

$V5 = 1$ if $.3 \leq VACP < .4$, $= 0$ otherwise

$V6 = 1$ if $.4 \leq VACP < .5$, $= 0$ otherwise

$V7 = 1$ if $VACP \geq .5$, $= 0$ otherwise

Other Variables

$PRICE_{70}/PRICE_{60}$ Estimate of ratio of 1970 average housing unit price to 1960 average housing unit price, for unchanged units existing in both 1960 and 1970

$\Delta PRICE/PRICE_{60}$ Percentage change in housing unit price 1960 to 1970 ($\Delta PRICE/PRICE_{60} = (PRICE_{70}/PRICE_{60}) - 1$)

OPEN Estimate of fraction of land both vacant and not subject to minimum lot size zoning restrictions ($OPEN = UZ \cdot VACANT\ ACRES_{60}/TOTAL\ ACRES$)

Delta Convention

a "Δ" always refers to the simple arithmetic difference between the 1970 and 1960 observation, thus

$\Delta PRICE = PRICE_{70} - PRICE_{60}$

$\Delta VACANT = VACANT_{70} - VACANT_{60}$

NOTES

[1]This model of housing supply is developed in a more detailed fashion in Bradbury (1976), as well as Bradbury et al. (1975) for new construction and Bradbury (forthcoming) for conversion-retirement.

[2]It can be argued that this sounds very much like the Urban Renewal program, which did take land from private use and clear it. However, that land was largely in residential use ("slums"), in contrast to this simulation, and in addition, except through unplanned program delays, the land did not become vacant on the private market. Local governments, in general, planned the uses to which the cleared land would be put (with an eye to "the public interest," which might bear some relationship to what the market would do with the land without planning), and then found private developers to carry out the plans.

[3]In addition, there might be second-round effects on housing supply through the land market which have not been explicitly modelled. For example, the taking of nonresidential land as of the beginning of the period may cause more contemporaneous (during the decade) changes in nonresidential nonvacant land use that would also be expected to affect residential new construction activity.

[4]These responses to a 10% price increment should be divided by ten to be comparable to elasticity estimates. The numbers obtained in that way are considerably higher than the price elasticity of the housing stock through new construction because they express the change in the amount of new construction relative to total (control value) decade new construction, whereas the price elasticity expresses decade new construction response to price change relative to total 1960 stock.

REFERENCES

Bradbury, Katharine. 1976. Housing supply in a metropolitan area. Ph.D. dissertation, Massachusetts Institute of Technology.

Bradbury, Katharine. Forthcoming. Changes in urban housing supplies through conversion and retirement. Institute for Research on Poverty, Discussion Paper 417-77. University of Wisconsin-Madison.

Bradbury, Katharine; Engle, Robert; Irvine, Owen; and Rothenberg, Jerome. Forthcoming. Simultaneous estimation of the supply and demand for household location in a multi-zoned metropolitan area. In _NBER studies in income and wealth_, ed. Gregory K. Ingram. Conference on Economics of Residential Location and Urban Housing Markets, Cambridge, Massachusetts, May 15-16, 1975.

DeLeeuw, Frank; Marshall, Sue; Ozanne, Larry; Schnare, Ann; Struik, Andrew; and Struyk, Raymond. 1974. The market effects of housing policies. Paper 208-23. The Urban Institute, Washington, D.C.

DeLeeuw, Frank, and Struyk, Raymond J. 1975. The web of urban housing. Washington, D.C.: The Urban Institute.

Ingram, Gregory K.; Kain, John F.; and Ginn, J. Royce. 1972. _The Detroit prototype of the NBER urban simulation model_. New York: National Bureau of Economic Research.

Muth, Richard F. 1969. _Cities and housing_. Chicago: University of Chicago Press.

Muth, Richard F. 1961. The spatial structure of the housing market. _Papers and proceedings of the Regional Science Association_, vol. 7, pp. 207-220.

ADDITIONAL DATA SOURCES

Metropolitan Area Planning Council (MAPC). 1972. Residential Zoning as of March 1972. Boston: MAPC.

U.S. Bureau of the Census. 1960. Census Tract Summary Tape. Boston area. Census of Housing and Population 1960.

U.S. Bureau of the Census. 1963. States and small areas. Part 4: Iowa-Massachusetts. Census of Housing 1960, vol. 1. Washington, D.C.: U.S. Government Printing Office.

U.S. Bureau of the Census. 1970. Fifth Count Tape. Minor Civil Divisions, Census Tracts. Census of Housing 1970.

U.S. Bureau of the Census. 1972. Housing characteristics for states, cities, and counties. Part 23: Massachusetts. Census of Housing 1970, vol. 1. Washington, D.C.: U.S. Government Printing Office.

Vogt, Ivers, and Associates. 1964. 1963 comprehensive land use inventory report. Boston.