DYNAMIC MODELING OF NEIGHBORHOOD TRANSITION

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Neighborhood transition is a phenomenon that has been before the public for some time. This process can be described, locally at least, using the Chicago housing market. As pointed out by Berry (1976), between 1960 and 1970, 482,000 new housing units were built in the Chicago SMSA, while the number of households increased by only 285,000; a ratio of 1.7 new housing units for each new family. The effect of this was to promote a series of moves by upwardly mobile families to suburban areas which in turn exerted downward pressure on the prices of older housing units. The rapid occupancy changes in neighborhoods have had effects in certain areas in terms of the socioeconomic environment and school system. Measures leading to a quantitative understanding of the process of neighborhood change are obviously desirable. A policy decision regarding intervention into this process must be preceded by an understanding of the underlying mechanism and how certain policy decisions affect this mechanism.

This paper contains the results of a pilot study aimed at the development of a model for predicting the course and extent of neighborhood racial change. Such a predictive model is necessary for diagnosing whether a certain neighborhood needs intervention on the part of the housing authorities or the local government and for deciding on the extent of intervention. This will also enable us to classify neighborhoods according to their future prospects which should be an important consideration in the allocation of public community development funds.

In the present pilot study we focus on the Austin community in the city of Chicago. Austin is located on the west side of Chicago, east of the suburb of Oak Park. As a logical first step it was decided that an analysis of changes in real estate prices over time should form the basis for the study of neighborhood transition. For this analysis we turned to the data base that has been developed by Berry (1976), consisting of information for 30,000 transactions that took place in Chicago between 1968 and 1972. For each transaction, the location of the unit, its selling price, and the date of transaction are available. In addition, for many of the transactions involving single family dwellings, the assessed values of land and structure are provided. In order to detect possible price shifts, a regression analysis was performed under the assumption that the logarithm of deflated selling price is a polynomial function of time plus a linear function of the logarithms of assessed values of land and structure (to control for variations in housing characteristics and lot size). For the purpose of this regression, data pertaining to census tracts 2514 thru 2519 within the Austin area was used. Also, blocks were grouped into somewhat homogeneous clusters with each cluster being associated with a separate polynomial in time to account for the possibly different dynamic effects in the various clusters. Our analysis showed that prices did not undergo significant change when a neighbhood was experiencing racial transition. Numerous studies have failed to find significant price declines during and after racial transition. See Pascal (1970) for a discussion of such studies. Our efforts were then directed toward finding a significant measure of racial change in a neighborhood.

Our main finding is that the process of neighborhood transition is clearly reflected in the corresponding density of single family house transactions. This can be seen by examining some examples of frequency histograms as shown in Figure 1. Figure 1 shows the frequencies of transactions taking place in intervals of 200 days between 1968 January and 1971 December, within portions of tracts 2518, 2519, and 2520. We notice that each of these histograms starts at a low level, builds up to a peak, and recedes. There is, for instance, a flurry of selling activity in 2518C around the time point of 200 days, and almost no activity after 1000 days. We propose that what we are observing here is panic selling. Under normal circumstances, one would expect a constant turnover rate resulting in a uniform density of transactions. However in a panic market the percent per year sold to the emerging race in an area can be assumed to be proportional to the number of units presently held by the receding race. This is because panic selling requires a readily available housing stock in order to continue propagation. One would, of course, also expect normal selling activity, but the normal activity should be swamped by the panic effect. The panic selling process can be characterized mathematically using a difference equation whose solution yields a logistic type curve for the transaction volume. The mathematical details are given in the next section which also contains results of fitting such a logistic curve to observed data pertaining to a specific part of Austin. The fit is remarkably good as indicated by the R^2 value shown there.

The above theory is based on the simplifying assumption that the area under consideration is a homogeneous closed community in the sense that units within the community do not interact with those outside the community. In reality, there will be some edge effects, but as long as they are not pronounced, one can still detect the panic effect through a single well-defined peak. In most of the histograms that we examined this was clearly the case. In some instances we observed contaminated distributions resulting from imperfect groupings of blocks. The contamination was especially visible when we aggregated the data along the lines of census tracts. This suggests that strategic grouping of blocks is necessary.

We have presented a rationale and results that give us a basis for detecting and characterizing panic selling. This is only a preliminary step in our overall modeling effort. Our goal is to be able to predict for any given locality if and when it will experience a transition. The questions that need to be answered are: given the existing pattern, at what point in time (if ever) will the transition evidence itself in the locality in question and what would be the time course of the transition? (The size of the peak measures both the speed of the transition and the total units susceptible to transition.) It is evident that the transition curve peaks at different times in the various localities we have considered, essentially giving rise to a travelling wave phenomenon. The next step would be to examine the different peaking times and magnitudes and to relate these to relevant geographic and socioeconomic aspects of the regions. The following concept borrowed from physics is helpful in this context. Consider two points in space and visualize a wave traveling from one point to the other. One characteristic of the wave is its velocity of propagation which is defined as distance/time taken for the wave to go from one point to the other. If we can estimate the velocity, then based on distance we would be able to predict the time between two peaks. Velocity would, of course, depend on a number of factors such as median education, median income, percent of foreign stock, percent of the population under 18, percent of units that are owner occupied, etc. (see Steinnes (1977)) for not only the immediate vicinity of the point under study, but also the intervening region (although not to the same extent as the former). It is clear, then, that velocity must be estimated as a function of these factors. This can be done using the data from the 1970 Census of Population and Housing, and transaction density curves of the type mentioned earlier. An estimate for the size of the peak can also be obtained in a similar manner. Finally, given a point in space for which a prediction has to be make, our strategy would be to consider the locality closest to it which has already undergone a transition and then to estimate the relevant parameters.

The Quantitative Model

We assume the neighborhood in question is composed of white households of number w and black households of number b. The total number of single unit households, N, is fixed so that

$$w + b = N.$$

Since little, if any, new single units were built in the period and locale of our data a constant population assumption is justified. If the neighborhood in question is sufficiently close to a region undergoing racial change we postulate the following model to hold

$$\frac{1}{b}\left(\frac{db}{dt}\right) = \beta w$$

where β is a rate constant. Using this equation and

$$w + b = N$$

$$\frac{db}{dt} \simeq b(t) - b(t-1)$$

yields the model

$$b(t) = (1+\beta N)b(t-1) - \beta b^2(t-1) \qquad (1)$$

We propose to estimate $1+\beta N$ and β from transaction histogram data. However the data used should be selected such that the region in question is fairly certain to have experienced a racial transition in the time period 1968-1972. Using 1970, SMSA data for the Austin area we plotted the percent black households versus census tract blocks. It was then evident that several block groupings would produce the conditions:

1) racial transition probably complete by 1968,
2) racial transition probably took place almost wholly in the period 1968-72,
3) racial transition probably would not occur in 1968-72.

Selecting an area satisfying condition 2 produced the transaction histogram of Figure 1 labeled "Blocks from 2518,19,20". To statistically test (1) we generated a sample time series, $b_s(t)$ as follows. Call the histogram values $h_s(t)$. Then our model requires

$$b_s(t) - b_s(t-1) = h_s(t).$$

Thus

$$b_s(1) = b_s(0) + h_s(0)$$

$$b_s(2) = b_s(0) + h_s(0) + h_s(1)$$

$$\vdots$$

$$b_s(t) = b_s(0) + \sum_{j=0}^{t-1} h_s(j).$$

Since the $h_s(j)$ are all available as the histogram the $b_s(t)$ sample series is known except for $b_s(0)$. We assumed $b_s(0)$ values about the same order as

$$\sum_{j=0}^{t-1} h_s(j),$$

that is, we took $b_s(0)$ = 50, 75, 100, 125, 150, 200 single family units. We then selected the $b_s(0)$ that yielded minimum standard deviation about the regression plane

$$b(t) = (1+\hat{\beta}\hat{N})b(t-1) - \hat{\beta}b^2(t-1)$$

where $\hat{\beta}$ and $\hat{N}$ are least squares estimates of β and N. With $R^2 = 0.984$ we get the equation

$$\underset{(30.75)}{b(t) = 1.26b(t-1)} - \underset{(-5.25)}{0.00141b^2(t-1)} \qquad (2)$$

with the t values of the estimates in parentheses. Our estimates gave

$$\hat{\beta} = 0.00141$$

$$\hat{N} = 185.$$

A comparison of $b_s(t)$ for $b_s(0) = 100$ and a solution of (2) for $b(0) = 100$ is shown in Figure 2.

Note from Figure 2 the asymptotic character of the model response. The model predicts a total single family housing stock of 185 units which is the stable equilibrium value, say b_e, the model seeks. The equilibrium can be calculated as the solution of $b(t) \equiv b(t-1) = b_e$ in the equation

$$b_e = (1+\hat{\beta}\hat{N})b_e - \hat{\beta}b_e^{\,2}.$$

From 1970 SMSA data the total single family unit housing stock for the area used was 196 units.

Relationship to Tipping Theory

Since Grodzins (1957) first proposed the idea of a racial "tipping point," housing researchers have been trying to analyze racial change using this notion. Tipping can be defined as a distinct increase in the rate of racial transition which happens once the percentage black reaches a crucial level, the "tipping point". Grodzins proposed that the tipping point is 10% to 20%. The studies by Duncan and Duncan (1957) and Steines (1977) provide some confirmation for a tipping point. However, other researchers have failed to detect a tipping point (Rapkin and Grigsby (1960), Stinchcombe, et al (1969), and Wolf (1963)). For example, the studies by Wolf (1963) indicate a steady rate of racial change. Wolf's result is in contrast to our model which states

$$\frac{1}{w}\left(\frac{dw}{dt}\right) = -\beta b.$$

Our study tends to support the notion of tipping as defined above for a particular set of circumstances. As Rapkin and Grigsby (1960) have emphasized, the expectations which people have for a neighborhood are important determinants of behavior. In Chicago there is a long history of complete racial transition once the process begins. The area under investigation is located near areas that had undergone complete racial transition in the recent past. Thus, both blacks and whites probably formed similar expectations for the Austin area. This means that black demand in the area was strong because it was not expected to remain an all-white area. Given that blacks were willing to buy any house that was offered, the time path of racial transition follows the distribution of white tolerance levels for the percentage black. (See Schelling (1971) for more formal models of this type). This distribution of tolerance levels may or may not imply a tipping point greater than zero. However, our evidence of panic selling implies that the distribution of white tolerance levels was not uniform in the Austin area. Indeed unless one uses histograms that begin in time with values representative of normal transaction behavior it is questionable whether or not tipping phenomena will evidence itself.

We have tested our model to see if it could pick up tipping phenomena even though none of our histograms in Figure 1 clearly shows an "equilibrium" transaction rate preceeding the obvious panic selling rate. Specifically we tested the model

$$\dot{w}/w = -\beta(b-t_r)$$

where $t_r > 0$ is the tolerance level or threshold below which no panic selling occurs. Using $b + w = N$ and $\dot{w} = w(t) - w(t-1)$ gives the model

$$b(t) = [1+\beta(N+t_r)]b(t-1)-\beta b^2(t-1)-N\beta t_r. \quad (2)$$

Using the same data and $b_s(0)$ value as the testing of (1) we got ($R^2 = 0.984$) the equation

$$\underset{(2.72)}{b(t) = 1.292b(t-1)}-\underset{(-0.89)}{.001522b^2(t-1)}-\underset{(-0.07)}{2.0915} \quad (3)$$

and the estimates

$$\hat{N} = 190,\ \hat{\beta} = 0.001522,\ \hat{t}_r = 7.23.$$

While the low t values on $\hat{\beta}$ and $N\beta t_r$ are disappointing, the sign and percent equivalent of

$$\hat{t}_r\left(= \frac{\hat{t}_r \times 100}{\hat{N}}\right) = 3.8\%$$

are what one would expect. Further, the autoregressive nature of b(t) would tend to lower these t values and compel one to judge the model fit more on the total R^2 and on how well the model predicts $b_s(t)$. On this score equation (3) essentially duplicates the data fit shown in Figure 2.

References

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2518C

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MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
   200.        26     **************************
   400.         4     ****
   600.         3     ***
   800.         3     ***
  1000.         0
  1200.         1     *
  1400.         0
  1600.         1     *
  1800.         1     *
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2519A

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MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
   200.        15     ***************
   400.        24     ************************
   600.        16     ****************
   800.        16     ****************
  1000.         7     *******
  1200.         4     ****
  1400.         7     *******
  1600.         9     *********
  1800.         1     *
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2519C

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MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
     0.         1     *
   200.        25     *************************
   400.        30     ******************************
   600.         4     ****
   800.        13     *************
  1000.        11     ***********
  1200.         8     ********
  1400.         5     *****
  1600.         4     ****
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MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
     0.         9     *********
   200.        16     ****************
   400.        12     ************
   600.         6     ******
   800.         6     ******
  1000.         8     ********
  1200.         9     *********
  1400.         5     *****
  1600.         4     ****
  1800.         1     *
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Blocks
from
2518,19,20

FIGURE 1.

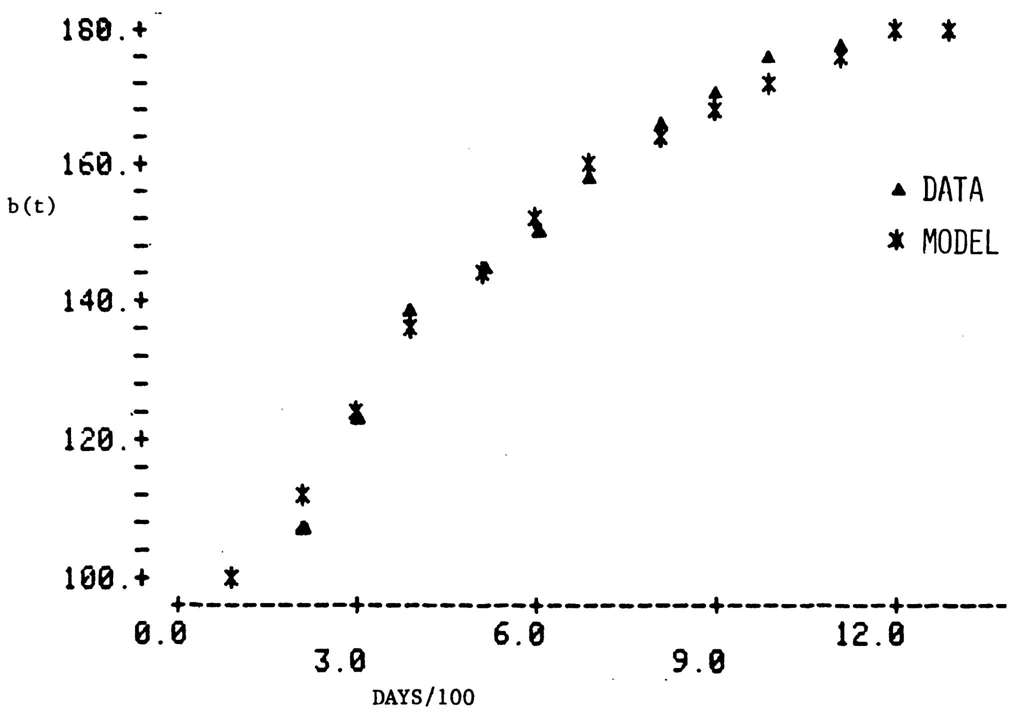

FIGURE 2.