Small-Area Population Estimation in Absorption Analysis

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Abstract. **In spite of a recognized need for market analysis in real estate appraisal, little attention has been given to the development of a small-area population forecasting model. This paper presents a systematic and localized approach for forecasting population as an integral part of a real estate absorption analysis. The model includes capacity constraints developed from a tract-specific environmental inventory. Historical growth patterns are adjusted to reflect the potential for continued development within a designated submarket. Future demand is calculated from population growth that considers both historical levels of activity and potential for development. The combined approach provides a defensible basis for forecasting absorption.**

Introduction

The valid estimation of value often requires the development of a multi-year discounted cash flow analysis, which in turn requires an estimate of occupancy or the rate of sales for future time periods. Partially developed subdivisions, vacant shopping centers and unsold residential condominiums abound in virtually every major real estate market. Unfortunately, many if not most real estate projects developed in the eighties did not include carefully researched and appropriately anchored market feasibility or absorption analyses. Valuation and disposition of these properties challenges owners, lenders and analysts. As the number of sales decrease, determination of the future absorption in the market continues, and may increase in importance. An appropriately conceived and carefully developed absorption analysis can be the key to determining the value of the property and identifying an appropriate disposition strategy.

In many, if not most cases, the absorption analysis in an appraisal is given little serious consideration because forecasts are difficult to develop and defend. For many years real estate investors have been encouraged to conduct market studies and feasibility analyses that include an absorption forecast [15], [17]. More recently, comprehensive handbooks specifically for real estate market analysis have been developed by Clapp [5], Barrett and Blair [1], and Carn, Rabianski, Racster and Seldin [4]. Absorption estimate is often based upon the familiar "comparable" approach, which is one of the three basic approaches to the valuation of commercial real estate. Determination of absorption based on comparables is, however, not a forecast of future activity but rather an assumption that historical precedent is appropriate for transfer to the subject property. While sometimes this approach will yield acceptable results, often the analyst

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is confronted with a market in transition or one that has yet to be established. An estimate of market demand that is founded on the principle that most demand for real estate is based fundamentally on population and employment growth provides a much better, and ultimately more defensible approach to absorption estimation (see Kimball and Bloomberg [11]).

Absorption estimates based on population forecasts require the acceptance or development of small-area population forecasts that coincide with the market area for the subject property. For all but the largest (regional malls, resort communities) or most specialized (retirement communities, amusement parks, convention centers) real estate products, the market area can be defined by census tracts or block groups at the sub-county level. In spite of a recognized need for small-area population growth forecasts, the methods that are used for forecasting are inappropriate for most real estate analysts. What is needed is an acceptable approach for the development of small-area population forecasts for a defined market area.

This paper will provide a simple methodology for use in estimating small-area population growth. The method presented is a modified exponential growth model that uses land availability as a growth constraint. The model is relatively simple to develop and offers real estate analysts a cost-effective but more defensible approach to forecasting than reliance upon market comparables or forecasts that are based solely upon historical trends and relationships.

Background

There are a number of models that can be used to geographically allocate population into small areas within a region. These methods vary considerably from fairly simple models such as ratio correlation analysis to much more complex approaches that include linear programming and complex cohort-survival component models. The simple approaches generally use some type of "share" allocation procedure and assume

Exhibit 1
Apartment Absorption Comparables

Apartment Name	Total Units	Date of Completion	Current Occupancy	Estimated Monthly Absorption
Spicewood Springs Apartments	248	June 1984	77.0%	7.34
Summer Grove Apartments	124	July 1985	85.0%	8.11
Summit Creek Apartments	164	May 1986	35.0%	19.13
Martha's Vineyard Apartments	360	Sept. 1986	5.3%	19.00
Hunter's Chase Apartments	424	Feb. 1986	26.4%	16.00
Audubon Square Apartments	184	June 1986	24.5%	15.00
Country Court Apartments	150	Aug. 1984	85.0%	10.63
Totals/Avg:	1,654		39.7%	13.60

Note: Based on survey conducted in September, 1986.
Source: Author

that the historical proportion of growth within a small area will continue into future time periods. The more complex models actually attempt to replicate the aggregate behavior of people who currently reside in or who will move to the area being analyzed. All of these models have a characteristic not usually found in real estate forecasting—they are allocation procedures that proceed from the top down and thereby avoid the common error of forecasting excessive growth at the subcounty level.

To illustrate the problem with forecasting based only on market comparables an example based on actual activity in Austin, Texas is presented. In the middle eighties a large number of new apartment complexes were constructed in Austin. These complexes were attractively designed, well built and contained a wide assortment of unit and complex amenities. Demand for new units appeared to be strong, but overall the market was beginning to soften because migration into Austin had begun to slow down. A typical apartment appraisal at the time would include several comparable projects with their initial lease-up rates as shown in Exhibit 1.

The hypothetical subject apartment project was then compared with the comparables and an estimate of the likely rate of initial lease-up calculated. Based on this assessment, an absorption rate of 16 units per month was adopted for a recently completed 200-unit complex. Unfortunately for the developer, a complete assessment of market supply had not been conducted and it was not discerned until too late that other projects were under construction that would add 1,200 units to the market area at a time when future demand (based on projected population growth) was declining. The result was a lease-up of only 3.4 units per month at rates that were substantially below those assumed in the initial pro-forma. Within two years, the lender foreclosed on the developer and took over management of the apartment complex.

A careful review of the market conditions, and in particular, an objective assessment of the growth potential for the market area would have revealed the impending overbuilt market that caused the project to fail. The remainder of this report will describe a process for small-area growth allocation that can be used to determine the demand for new residential development, which will, in conjunction with a careful representation of competitive inventory, provide a better representation of market conditions.

Model Definition

As a result of guidelines promulgated by the Office of Thrift Supervision (OTS), many real estate appraisal assignments now require a discounted cash flow analysis that involves the forecasting of occupancy or sellout of the product under consideration. From a practical standpoint this requirement means that an absorption analysis that identifies the rate of sales or leasing activity must be developed. In many instances, the absorption analysis is based upon the recent experience of other similar properties in the area and not on the underlying cause of absorption, which is demand created by growth in population or employment. When a market study is incorporated into an appraisal, this deficiency is addressed through an examination of the supply and demand for the product under analysis. However, even in appraisals that incorporate market studies (see Wang, Webb and Cannon [18]), the demand portion of the equation is often assumed to be stable or increasing at recent historical rates and is not based on small-area population or employment forecasts.

In the appendix to this paper a brief description of the types of models that are most often used for forecasting population is presented along with an identification of the problems these models pose for the real estate analyst. The simple models extrapolate the recent past without regard to the changing character of the urban landscape. The more complex models are much too expensive and complicated for most market research and appraisal firms to incorporate in their approach. What is needed is an approach that is cost effective and yet incoporates enough of the dynamic aspects of the more complex approaches to improve the accuracy of the forecast technique. The model proposed in this paper fills the gap between simple and more complex approaches.

The suggested model concept is very straightforward. The market area under consideration is divided into a number of small geographic units, usually census tracts. Historical census information is gathered and a trend extrapolation forecast is prepared using one of the simple methods discussed in the appendix. However, this forecast is modified or constrained by the availability of developable land within each of the small areas under analysis. Thus when population reaches "capacity" based on land availability in each zone, growth slows and is diverted into other census tracts within the region. In an earlier formulation of this model, Greenberg, Krueckeberg and Michaelson specified density ceilings for each subgroup (e.g., urban, rural and suburban) which were aggregated to the tract [9]. The model proposed here specifies the carrying capacity of each census tract and differs from the Newling density ceiling because it incorporates the concept of land use into the density calculation. An exogenously defined density assumption is used to determine the rate at which land will be consumed (developed) but the "ceiling" is defined by the amount of "developable" land.

The formulation of a capacity-constrained population growth model is developed in the following manner. First, the trend extrapolation model is specified, in this case as an exponential growth formulation:

$$P_{(t+n)} = P_{(t)} * (1+R)^n, \qquad (1)$$

where:

$P_{(t)}$ = population in the tth period,
$P_{(t+n)}$ = population in the tth + nth period,
R = the average percent change in population, over preceding time periods, $t-1$, $t-2$, etc.

The average percent change during the previous time periods is calculated for n periods as shown below.

$$R = [\frac{P_{(t)}}{P_{(t-n)}}]^{1/n} - 1. \qquad (2)$$

It is apparent that forecasting the continuation of an accelerating rate of growth in an area, particularly over long periods of time, will produce absurd results. Imposing a capacity constraint or ceiling on this growth will result in a diminution in the rate of growth as the forecasted population nears the ceiling. The capacity constraint can be formulated as follows:

$$P_{(t+n)} = [(K - P_{(t)}) * (U)^n], \qquad (3)$$

where:

K = the upper limit of population in the tract,
U = the unused capacity ratio,

and:

$$U = \left[\frac{K - P_{(t)}}{K - P_{(t-n)}}\right]^{1/n} \tag{4}$$

for (n) historical periods of time. This formulation is documented in the work of Brail [2] but leaves unresolved three important questions:

(1) What is the upper limit (K) of population $P_{(t+n)}$ for each tract?,
(2) How are declining tracts handled?, and
(3) How are individual tract forecasts related to county-level forecasts?

In most urban areas there will be at least as many tracts with stable or declining population as there are tracts with population increases. This creates a situation where some tracts may be completely emptied of population during the forecast period, if the recent trends are extrapolated. While possible (particularly in central city areas where commercial development may be replacing residential uses), it is unlikely that any residential area will lose all of its population. Thus a minimum population or "floor" must also be established and added to the estimation procedure. A mechanism must be established for balancing the growth potential on an individual tract basis with the county or regional forecast. Both of these issues are addressed later, after the development of the capacity constraint ceiling.

A land use planning concept proposed by land use planners at the University of Pennsylvania (see McHarg [13]) articulated the concept of ecological inventories being prepared to set an ideal population level (or capacity). In the simplified form used here, the concept can be defined as the available developable land within a specified geographic area, the key words being available and developable. As formulated in this model, available land can be calculated as vacant land ecologically "suitable" for development. Areas that are "unsuitable" may vary from region to region based on local conditions but should include, at a minimum, bodies of water, flood plains, wetlands, federal lands, parks, steep slopes and sensitive environmental features. Using a locally identified inventory of unsuitable areas for development, a theoretical population capacity can be formulated for each tract as follows:

$$K_a = [T_a - (L_a + F_a)] * D_a, \tag{5}$$

where:

T_a = total acres in census tract (a),
L_a = areas already developed in acres,
F_a = undeveloped flood plains, bodies of water and other areas unsuitable for development,
D_a = locally prescribed (or average) development densities expressed in number of people/acre;

and:

$$D = N_a * H_{at}, \tag{6}$$

where:

N_a = the prescribed number of units per acre (or typical unit densities) for the tract,

H_at = the average household size of tract (a) at the last census period (t).

Declining tracts can be constrained at a lower limit by setting K equal to the current population or at zero if the analyst believes that population decline will continue.

The final step in the process is to balance the tract-specific (bottom-up) forecasts with a county or regional (top-down) forecast. This is necessary in order to maintain comparability among counties (or planning regions) and to impose a realistic limit on a forecast that builds up from the small area.

The tracts that are rapidly growing may create, when added together, a county forecast that is different than the level anticipated by the state or regional planning agency. If there is a difference, then the tract level forecasts can be adjusted for period $(t+1)$ by using the following formula:

$$AP_{a(t+1)} = P_{a(t+1)} * \frac{P^c}{\sum_1^m P_{i(t+1)}}, \tag{7}$$

where:

$AP_{a(t+1)}$ = the adjusted ith tract level forecast,

$P_{i(t+1)}$ = the unadjusted ith tract level forecast,

P^c = the county level forecast to be matched,

$\sum_i^m P_{i(t+1)}$ = the summation of all m unadjusted tract level forecasts.

While it appears that only rapidly growing tracts should be adjusted to dampen their volatility, convergence on the county "control" total or regional forecast cannot be achieved unless all tracts are adjusted in a similar manner. Once the adjustment is completed, the analyst then has not only an areawide forecast but also subarea or tract level forecasts that can be used individually or added together to create a relevant market area for the proposed project.

Case Study

A simple example using County "A," containing five census tracts, can be developed to illustrate the model. A recently completed apartment project is located in Tract 1. For the last thirty years this part of the county consistently has received a substantial proportion of the county's population growth as shown in Exhibit 2. In 1960, Tract 1 contained 5,000 people and 26.3% of the county population. By 1990 this area had grown to 15,000 people and constituted 44.1% of the county population.

Among the desirable attributes of Tract 1 are abundant streams, lakes and rolling terrain that, combined with easy access to the Central Business District, have made this the most rapidly growing part of the county.

Exhibit 2
Historical Population: County A

Tract	1960	1970	1980	1990
1	5,000	8,000	11,000	15,000
2	3,000	3,500	3,900	4,800
3	3,000	3,500	4,000	5,000
4	4,000	5,000	6,500	7,000
5	4,000	5,000	2,600	2,200
Totals	19,000	23,000	28,000	34,000

Source: Author

Exhibit 3
Unconstrained Population Forecast

Tract	1990	2000
1	15,000	21,634
2	4,800	5,614
3	5,000	5,928
4	7,000	8,435
5	2,200	1,803
Totals	34,000	43,414

Note: Exponential growth forecast based on 30-year trend
Source: Author

A forecast of the historical growth rates for the year 2000 shown in Exhibit 3 will result in a forecasted population of 43,414 for the county with 49.8% located within Tract 1. The unconstrained forecast of growth in the tract would average 663 people per year.

There are a number of factors that may cause growth to slow in a particular area. The area may be placed under a development moratorium, suitable land for development may be substantially depleted, land costs may become too high for profitable development, or overall growth in the region may decline. In our simplified model, the only constraint considered is the availability of suitable land. For the purpose of demonstrating the model, we assume that each tract has a capacity to accommodate 20,000 people at current development densities. With capacity "k" set to a uniform level of 20,000 people per tract the capacity-constrained forecast is shown in Exhibit 4. Assuming that the growth between 1990 and 2000 is evenly allocated, the constrained average annual growth rate for Tract 1 would be 153 people per year.

In our example, County "A," the county commissioners have established a target population forecast for 2000 at 36,000. Recent rapid growth has caused bottlenecks on a number of major thoroughfares, and the regional wastewater treatment plant is already running at capacity. Consequently, a slow-growth policy has been implemented and is likely to have a constricting influence on the demand for housing.

Exhibit 4
Constrained Population Forecast

Tract	1990	2000
1	15,000	16,533
2	4,800	5,357
3	5,000	5,613
4	7,000	7,869
5	2,200	1,803
Totals	34,000	37,175

Note: Build-out capacity for each tract assumed to be 20,000 people
Source: Author

By balancing the forecasted population growth with the county-adopted forecast, a further reduction in Tract 1 population is anticipated and is shown in Exhibit 5. With only 101 people per year anticipated, the lease-up rate of an apartment complex is likely to take four or five years instead of one, with profound impacts on the discounted cash flow and value.

With a more accurate population forecast, the rate of absorption anticipated for the recently completed 200-unit apartment complex can be developed. In the case presented earlier, initial lease-up of the subject complex was estimated to be 16 units per month with lease-up to a stabilized 95% occupancy in less than one year. In the example above, the demand for units in Tract 1 is approximately 3.33 units per month (assuming household size of 2.5). If 100% of the population lives in multifamily units, and there are no competitive projects, then 40 units per year are available for absorption in the subject. At that rate of absorption, the lease-up would take almost five years as shown in Exhibit 6, with a potentially disastrous difference in projected cash flow resulting from an inappropriate forecast of leasing activity.

As shown above, an appraisal or feasibility analysis that relies on carefully prepared population forecasts that are then used in conjunction with the appraiser or analyst's market data may substantially improve the results of the study.

Exhibit 5
Constrained County Population Forecast

Tract	1990	2000
1	15,000	16,011
2	4,800	5,187
3	5,000	5,436
4	7,000	7,621
5	2,200	1,745
Totals	34,000	36,000

Note: Build-out capacity of 20,000 used with a county total of 36,000
Source: Author

Exhibit 6
Absorption Estimates Based on Alternate Methods

		Approach Based on Model			
Year	Tract Annual Change	HH Size (1990)	Unit Demand	Calculated Monthly Absorption	Lease-up to 95% Occupancy
Year 1	101	2.5	40	3.4	20.2%
Year 2	101	2.5	40	3.4	40.4%
Year 3	101	2.5	40	3.4	60.6%
Year 4	101	2.5	40	3.4	80.8%
Year 5	101	2.5	40	3.4	95.0%

Approach Based on Comparables		
Year	Comparable Monthly Absorption	Lease-up to 95% Occupancy
Year 1	16.0	95.0%
Year 2	16.0	...
Year 3	16.0	...
Year 4	16.0	...
Year 5	16.0	...

Source: Author

Conclusions

In spite of substantial advocacy in the literature for detailed market analysis and absorption estimates, many appraisers and analysts rely on the recent experience of comparable properties to estimate the rate of sales or leasing activity in a discounted cash flow analysis. While useful when *relevant* comparables are available or local conditions are relatively stable, this approach is severely limited when applied to projects in dynamic markets. When a project-specific absorption study is prepared using a detailed supply and demand analysis, a market-area or tract-level demand forecast is a prerequisite. The approach proposed in this paper provides the market analyst with a relatively simple method for forecasting population at the census tract level. Historical trend analysis is combined with the land use capacity concept based on ecological inventories to result in a population carrying capacity for each tract. These capacities are then used to moderate the growth forecast for each tract. As the extrapolated population approaches the tract capacity ceiling, growth is diverted to other areas. This pattern of development is often found in urban areas where rapid growth will fill up one area and then spill over into adjacent markets as land availability decreases and prices rise. Using population as a basis for absorption these forecasts can be used to estimate the demand for residential projects including subdivisions or population-driven commercial projects such as shopping centers.

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Appendix

One of the most common methods used to allocate population to small areas is the simple trend extrapolation method. There are actually several methods that fall under the category of trend extrapolation but the common assumption is that historical trends evident within a region will continue into the future much as they have in the past. These methods include: simple ratio correlation, constant share, linear extrapolation of share, and the exponential extrapolation of shares (see Isard [10], pp. 5–50, and Brail [2]). Generally, areas that are experiencing rapid growth are better explained through a linear or exponential extrapolation. However, there is some evidence that the ratio correlation or constant share approach yields very good results for short-term forecasts (Bunch [3]). Empirical analysis of urban regions shows that most contain areas that have remained stable in contrast to other areas (typically at the urban fringe) that have experienced rapid or even explosive growth. A significant problem with the simple models is that over longer periods of time they cannot accurately predict the population allocation among both stable and rapidly growing submarkets.

The more complex models generally employ either a gravity model simulation, a cohort-survival component or a linear programming model to replicate the behavior of people within an urban region. The gravity model applies the gravity concept in physics to the location decision-making process. The underlying premise in this approach is that the attractiveness of a small area is positively related to the "mass" (in this case population) and inversely related to the distance from other areas within the region (see Isard [10], pp. 493–568; Ghosh and Rushton [8]). This approach has been carefully developed and refined over the last thirty years and is currently in operation as a transportation planning tool in a number of cities around the country (Putnam [14]; Watterson [19]; Clark [6]). There are several advantages to the use of gravity models. The most significant advantage is that the model simulates the location decisionmaking process rather than simply extrapolating historical trends. It has, in theory at least, the ability to "recalibrate" in response to the growth and maturing of subareas within the region. Because of its heavy emphasis on the distance or time impedance factor and the sensitivity to adjustments in this parameter, it is becoming the favored model among transportation planners (Douglas, Whitmore and Jacob [7]). A significant disadvantage to the use of this model is the difficulty and expense of developing the baseline demographic database and transportation network and the need to accurately update the future network to reflect changes in capacity and trip generation. Clearly, this approach has only limited applicability for market analysts and demographers who use population forecasts as only one of many inputs in the evaluation process. In some areas forecasts using this approach have been developed by state or regional planning agencies and may be available to the analyst, but often these forecasts are out of date, questionable, or not available at all.

Another widely used model for small-area forecasting is the cohort-component model. This model relies on detailed demographic data to forecast future population growth (or decline). Age-specific fertility and mortality rates are obtained and used to determine how many people will be born or will survive into future time periods. A key assumption incorporated into this analysis is the migration rate anticipated for each age group. Clearly, the rate of migration can have a significant impact on the rate of population growth. Also, the method is much more accurate at larger geographic levels where migration is more stable and vital statistics are more accurate and less volatile. This method also has the advantage of providing detailed age, sex and ethnicity data for the estimated populations (see Rives and Serow [16]). Unfortunately, the vital rates and migration estimates used in the forecasts are typically collected at the countywide level and may be substantially different in subcounty areas. Nevertheless, the advantages of providing detailed demographic data at the census tract level make this a valuable approach, particularly for school district and health care planners.

Recently some very interesting research has been conducted in the use of a linear programming or econometric model that adds measurably to the simulation of the urban development process and incorporates economic "bid rent theory" and land secession concepts into the model design (see Lee and Goldsmith [12]). While considerable progress has been made in the development and refinement of this model, it also shares with the gravity model the need for a tremendous volume of data and updating of that data as local parameters change.