FORECASTING THE COST AND REVENUE IMPLICATIONS OF THE DEVELOPMENT OF A SUBURBAN TOWN

by

PETER MURRAY ALLAMAN

B.A., Otterbein College
1963

A.M., Harvard University
1967

M.C.P., Massachusetts Institute of Technology
1967

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Signature of Author...
Department of Urban Studies and Planning
13 January 1975

Certified by..............   ....
Thesis Supervisor

Accepted by...
Chairman, Department of Urban Studies and Planning

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Peter M. Allaman

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The problem of forecasting the budget for a small suburban town is the central focus of this dissertation. The problem was chosen because growth at the local level appears to be essentially determined by forces outside local control, so that planning should concentrate on forecasting and efficiently accomodating that growth which will occur. Past methods of projection, however, have failed to deal with an important aspect of the problem -- that of metropolitan-local interactions. They either treat new towns or existing municipalities which are entire urbanized areas, or assume that trends are stable. By the use of an already-developed, comprehensive model of a metropolitan area we are able to realistically represent this interface. A highly-disaggregated model of school enrollment and budget determination is formulated which uses simulation methodology and econometric techniques to integrate national, regional, and local data into a forecast. The model is applied to the Town of Guilford, Connecticut.

The determinants of suburbanization are reviewed initially, and powerful external forces are seen to be at work. We then review literature on the budget formation problem and present a set of desiderata for a forecasting tool. Following a discussion of modeling issues, we examine in some detail the problem of estimating school enrollments. It is found that extensive disaggregation of households by type of head, type of unit and migration status is necessary to capture large variations in numbers and age distributions of children. In addition, variation of enrollment rates and the age structure over time must be incorporated into the methodology. A system of econometrically-estimated equations is employed to predict the budget. This system takes as inputs the output of the school enrollment module and the SMSA model. Conclusions and fruitful directions for research are discussed.

Thesis Supervisor: Aaron Fleisher

Title: Professor of Urban Studies and Planning

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Chapter 1

Introduction

Recently, there has been an upsurge in interest in urban growth and its effects, as well as in policies for its management. While concern may be expressed nationally, such concerns are rapidly translated into state, regional, and local terms. The local level is, of course, where the problems and effects of growth are manifested. While poorly-understood national demographic and economic forces impinge on regions, these effects are in turn directly felt by inhabitants of local municipalities.

More often than not, the symptom of distress is a change in the balance of expenditures and revenues. Only recently, however, have studies attempted to deal systematically with the effects of growth at the local level, and only a few of these have dealt explicitly with the question of what determines costs and revenues, and how they might be projected. Diverse efforts by Whitelaw, Scott, Owen, the RAND Corporation, and the Real Estate Research Corporation have attempted, in various ways, to consider the question of municipal expenditures and revenues in relation to these external processes.[1] The models and techniques have been limited to cities or towns

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[1] William E. Whitelaw, "An Econometric Analysis of a Muniicipal Budgetary Process Based on Time-Series Data," unpublished Ph.D. dissertation, M.I.T. Dept. of Economics, 1968; Claudia D. Scott, Forecasting Local Government Spending, Urban Institute (Washington, D.C.: 1972);
Patricia A. Owen, "A Computerized Model for Analysing the Financial Impact of Developments," Proceedings of the Winter Simulation Conference (Jan., 1974): 351-359;
The RAND Corporation,
Urban Policy Analysis Group, "Alternative Growth Strategies for San Jose: Initial Report of the RAND Urban Policy Analysis Project," Working Note WN-7657-NSF (Santa Monica, California: 1971);
Real Estate Research Corporation, Economic and Financial Feasibility Models for New Community Development (Washington, D.C.: 1971).

with an undeveloped rural hinterland (Whitelaw, RAND), a central city (Scott), or new towns (Owen, Real Estate Research). None has considered the problem of modeling the development of a small, suburban, fringe town which is by necessity closely linked to a larger metropolitan area.

The purpose of this work is to provide at least partial answers to the following questions:

1. What are the relations of costs and revenues in a small suburban town to the major observable determinants, such as numbers of households, and, 2) how does one incorporate the results of this examination into a projection method which produces estimates useful to a local decision maker, such as a superintendent of schools or a member of the board of selectmen.

One central thesis of this work is that it is critically important to represent the interface between the local town and its surrounding metropolitan area: what the town sends to and receives from the region in terms of households, jobs, and people. This is so because of the large flows across the boundaries and the possibility that changes in these flows which are small from a regional perspective may have a large impact on the local town. In addition, the flows are not entirely controllable at the local level and anticipation of trends may be the primary response open to many towns.

A second thesis is the importance of disaggregation in approaching the modeling of the processes which occur. This is so principally because different segments of the population can respond to changes, or act, differently, and, if the "mix" of the population changes, the observed effects can be quite different. As a consequence of this view, it is hypothesised that the behavior of different types of individuals is quite different, and that it is necessary to represent the determinants of demand at a high degree of disaggregation in order to account for observed behavior. Disaggregation is also hypothesised to be important to explaining the process of budget determination in a town -- budget categories must be broken down into relatively homogeneous classes.

A third thesis is that the formation of families and the education of the children involved is critical to the process of budget determination in suburban towns, so that the lags and time-varying relations involved in determining the size and age distribution of children, as well as the amount of public school enrollment generated, must be included in a model.

Experimentation and projection were goals of the work, so that it was necessary to be able to change assumption or inputs readily. Additionally, the stress on disaggregation implied a model which was complex, or at least unwieldy. The goal of experimentation and possible complexity called for the use of computer simulation. This is the approach employed in the study, and we comment on various aspects of its use in a later chapter.

What follows, then, is a report on the problems encountered and the precedures developed in the course of researching these questions. Although the investigation was carried out in one particular town -- Guilford, Connecticut, a part of the New Haven SMSA -- the insights gained and many of the techniques used should be applicable elsewhere.

Why is it sensible to devote such effort in the direction of analysing, and hopefully explaining and predicting the effect of growth on town budgets? Have not most of the efforts of planners been in the direction of controlling growth? One might respond that it is necessary to understand the dynamics of a system before control policies can be sensibly devised and implemented.

We propose a somewhat different argument, however. Chapter 2 is devoted to the task of illustrating the proposition that growth from the suburbanization of the population is to a large extent outside the control of the local municipality. It also illustrates the need to consider the metropolitan area as a whole even when concentrating on a single municipality.

If one cannot control, then one option left is to forecast better, so that the expected changes may be accommodated with the least pain. Chapter 3 considers the amount of complexity which seems to be called for in the development of a forecasting tool. It also reviews several past studies in an attempt to draw up a list of desirable features to include in such a tool.

Since the primary method of this work is computer simulation, Chapter 4 discusses issues surrounding its use. We point out the weaknesses of an axiomatic mathematical approach and claim that an algorithm can be an analytic proposition in its own right -- that propositions about phenomena linked by computer logic constitute theory of a flexible variety. We then discuss one of the more important aspects of a simulation approach -- the disaggregation into many classes of observation, whether households, dwelling units, etc. We suggest that a forte of simulation is disaggregation, and the lack of the need to find continuous approximations to discontinuous structures.

In Chapter 5 we discuss in some detail the problem of estimating public school enrollments. Considerable attention is directed toward the analysis of the variation in the number and distribution by age of children when the age, ethnicity and education of the household head, the tenure and price of the dwelling unit, and the length of time in the unit are controlled. Ways of introducing time-varying effects of changing family size and age mix of children, and changing enrollment rates are discussed. A step-by-step explanation of the estimation method is presented.

In Chapter 6 we integrate these estimates with yearly estimates of the state of the town from the SMSA model to produce estimates of line items in the town budget. The method employed is a system of econometrically-estimated equations. It is possible to fairly closely describe the response of the town budget to changes in levels of activity within the town.

The Research Site

Rather than to study superficially a large number of towns, the strategy pursued here was to study a single municipality in greater detail, while utilizing coefficients estimated from national data. The results are a particular application of a more general methodology, and the study thus stands between a case study, from which generalizations are hazardous, and a random sample, which permits generalizations to the universe sampled. A brief discussion of the town is thus in order.

The particular setting for the study is the town of Guilford, Conn. The town of Guilford lies on the eastern edge of the New Haven SMSA (see Figure 1). While possessing many extraordinary features, it is prototypical in many respects of towns undergoing rural-to-urban conversion. While the southern part of the town consists of Long Island Sound shorefront property, salt marshes, and a relatively well-developed and historic residential section, the northern part is largely undeveloped, but has been experiencing increasing development in recent years. This will no doubt continue, as much of the land suitable for easy development elsewhere in the SMSA has been exploited in the post-world war two period.

Guilford has almost one fifth of the land area of the SMSA but its 1971 population density of 264 persons per square mile is only about one fifth of the SMSA average.[2] Under current zoning, the vacant buildable land in the town could accommodate 2 1/2 times the number of households as currently inhabit the town.[3]

In other respects Guilford is representative of the SMSA. Its 1970 median family income of $12,979 was fifth of the eleven towns in the SMSA, and its public school expenses of $821 per pupil in 1970-71 86% of the SMSA average. Its retail sales per capita were 90% of the SMSA average.[4]

In 1972 its adjusted tax rate was in the upper third of the SMSA, but the rate of change in the tax rate from 1971 was in the lower third.[5]

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[2] These remarks based on South Central Connecticut Economic Profile and Industrial Directory, 1973-1974, Greater New Haven Chamber of Commerce (New Haven: 1973), pp. 8-9.

[3] Based on data from Planning and Zoning Commission.

[4] Economic Profile, ibid.

[5] Ibid., pp. 46-47.

In the 1971-72 fiscal year, its indebtedness was only 22% of that permitted under Connecticut state law.[6]

The general picture which emerges is that of a town with tremendous potential for growth if the conditions in the region are favorable. Its response to that growth is the object of this study.

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[6]Guilford, Connecticut, <u>Annual Report, 1971-1972</u>, p. 48.

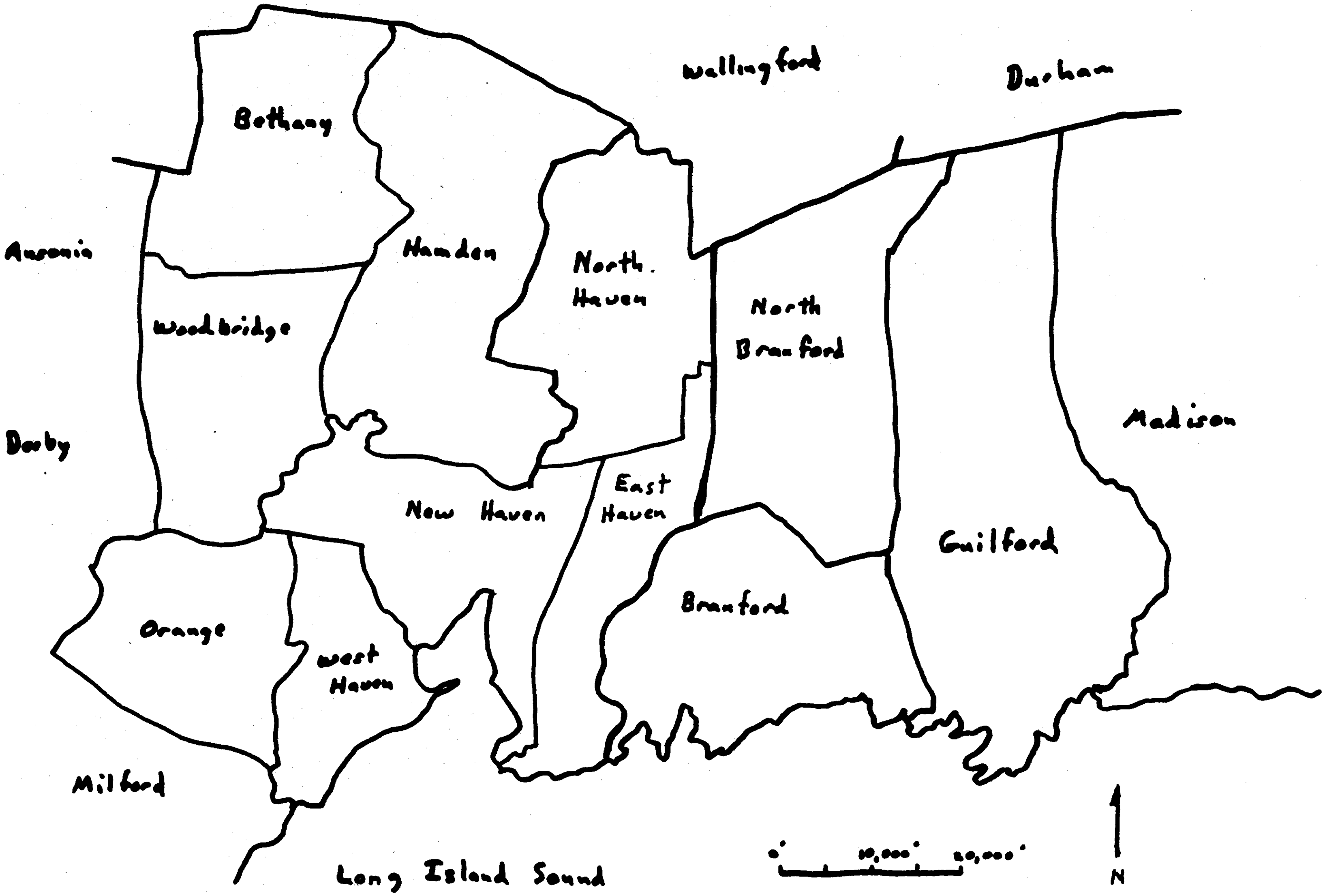

Figure 1

The New Haven Region

Chapter 2

Growth Outside Local Control

In dealing with the fiscal effects of suburbanization, it is necessary to understand why suburbanization takes place and what, if anything, can be done to control it at the local level. Chapter 2 is devoted to the task of illustrating the proposition that the growth and suburbanization of the population has been largely outside the control of the local municipality. It also illustrates the need to consider the metropolitan area as a whole even when concentrating on a single municipality.

In a very real sense, the individual community is hardly the master of its own fate. Powerful national forces, both within and outside of metropolitan areas, have in turn had a profound impact upon the distribution of population within metropolitan areas. Many explanations for the observed dispersal of population have been offered. We review several of these. They are by no means unanimous in their conclusions. On the contrary, numerous mutually inconsistent explanations abound, and careful empirical work to resolve the differences is still in its infancy. However, none of the explanations are inconsistent with the view that little can be done at the local level to reverse the trends. While certain communities may bias growth in one way or another, all could not simultaneously shut out growth. The communities which have been able to shut out growth may be able to do so because not all communities are trying to do so.

National Population Processes

The shift of the population from rural to urban areas is seen by many as the key to an explanation of the problems which beset metropolitan areas. In the President's Report on National Growth, 1972, great stress is placed on this trend.

The report points out that in the last 100 years, the country has virtually reversed the per cent of the population living in urban areas. In 1870 it was 25%, in 1970 it was 74%. It essentially argues that changing technology in farming, mining, fishing, and forestry, resulting in higher productivity, has vastly decreased employment opportunities in rural areas, and the growth of corporate farming has also hastened the demise of the small farmer. These changes have prompted much rural-to-urban migration, which, coupled with natural increase, have caused the rapid growth of many metropolitan areas.[1]

This is a curious argument indeed, as it focuses exclusively on "push" factors in rural areas while completely ignoring the even more startling changes in manufacturing technology which have created powerful "pulls" to metropolitan complexes, as well as circulation among them. Not only that, but metropolitan agglomerations seem to possess further advantages, sui generis, which perpetuate their own growth.[2]

---

[1] Domestic Council, Committee on National Growth, Report on National Growth, 1972, U.S. Government Printing Office (Washington, D.C.: 1972), pp. 4-17, and Tables 2, 6 and 7.

[2] See, for example, James Hester, Dispersal, Segregation, and Technological Change: A Computer Simulation Model of the Development of Large Metropolitan Areas in the United States During the Twentieth Century, Ph.D. dissertation, M.I.T. Department of Urban Studies and Planning (June 1970), Chapter 3, for a discussion of the impact of technology, and Harry W. Richardson, The Economics of Urban Size, D. C. Heath-Saxon House (Westmead, Farnborough Hants, England) and Lexington Books (Lexington, Mass.: 1973) for a recent discussion of agglomeration economies.

For whatever the reason, however, massive rural-to-urban shifts of the population have occurred, with a profound impact on metropolitan areas.

Of particular importance for the structure of metropolitan areas has been the racial composition of these shifts. Table 1 details net internal migration from 1870-1970. Examining the net internal migration by race reveals large net emigration of blacks from the South Atlantic and South Central areas, and large net immigration to the Middle Atlantic, East North Central, and Pacific areas. Of course, this is from rural to urban sections of the country. Since 1930, the net flows of blacks into the Middle Atlantic and East North Central areas have largely exceeded those of whites. This has had a profound impact on the character of metropolitan areas which we will discuss at greater length in the next section.

It should be pointed out, however, that rural-to-urban migration must dry up as a significant source of population increase for cities as a whole. For example, the amount of migration from farms in the 1960-1969 period is equal to two-thirds of the 1970 farm population.[3] As the Rockefeller Report notes, the bulk of population increase in the 1960's was from the expansion of the geographic boundaries of metropolitan areas and from natural increase within metropolitan areas. The percentage breakdown is approximately as shown in Table 2.

---

[3] Report, op. cit., Tables 6 and 8.

Table 1

NET INTERNAL MIGRATION BY CENSUS DIVISION, 1870-1970
Total and Black
[in thousands — denotes net outmigration]

Year	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
Total Population—Census Divisions									
1870-80	141	129	28	869	-39	-205	381	190	197
1880-90	403	832	399	1,081	-118	-247	268	300	506
1890-1900	494	1,085	597	-87	-217	-245	568	197	296
1900-10	496	1,882	503	-83	-91	-429	606	555	1,349
1910-20	298	798	1,274	-280	-36	-612	37	237	958
1920-30	28	1,252	1,160	-655	-634	-571	-23	-165	1,873
1930-40	-43	67	-101	-569	146	-364	-465	1	1,178
1940-50	-6	-163	343	-899	159	-1,043	-656	118	2,994
1950-60	18	313	694	-827	647	-1,466	-580	555	3,288
1960-70	316	9	-153	-599	1,332	-698	-42	307	2,547
Black Population—Census Divisions									
1870-80	5	19	20	16	-49	-56	45	—	—
1880-90	7	39	16	8	-73	-60	63	—	—
1890-1900	14	90	39	24	-182	-43	57	—	—
1900-10	8	87	46	10	-112	-110	51	6	14
1910-20	12	170	200	44	-162	-246	-46	11	18
1920-30	7	342	324	40	-509	-180	-60	-1	37
1930-40	5	166	108	20	-175	-123	-50	6	43
1940-50	25	387	494	35	-424	-485	-336	21	284
1950-60	60	436	504	37	-556	-622	-296	27	278
1960-70	72	540	356	26	-538	-560	-282	16	286

Source: Department of Commerce, Bureau of the Census.

Source: Domestic Council, Committee on National Growth, Report on National Growth, 1972, U.S. Government Printing Office (Washington, D.C.: 1972), Table 4.

Table 2

Components of Metropolitan Change: 1960-70

Source of Change	(Approximate) Per Cent of Change[4]
Territorial expansion	33%
Natural increase	50
Foreign immigration	11
Rural-urban migration	6

Even if these percentages were to continue and the birth rate were to stabilize at the replacement level, the contribution of rural-to-urban migration would be only 3-5 million persons of the expected 50-80 million additional persons in the U.S. by the year 2000, or 1-2 million per decade.

Whether, as Mills argues,[5] urbanization will slacken due to a slowing in the growth of manufacturing, or whether it will slow in logistic-curve fashion simply because the per cent urban is approaching the obvious upper limit of 100%, the basic point is clear: the U.S. is a metropolitan nation, and natural increase, whatever its rate, will have a much larger effect on the population growth of metropolitan areas as a whole than any other sources of change. Of course, intermetropolitan migration may have a larger impact on the size of particular metropolitan areas than natural increase in many instances, but its net effect on the balance between urban and rural areas is close to zero.[6]

---

[4]Commission on Population Growth and the American Future, Population and the American Future (1972), Chapter 3, and author's breakdown of foreign vs. rural-urban migration.

[5]Edwin S. Mills, Studies in the Structure of the Urban Economy, Resources for the Future, The Johns Hopkins Press (Baltimore: 1972), pp. 12-13.

[6]It is not exactly zero due to a recent tendency for suburban migration to overrun metropolitan-area boundaries, producing an apparent urban-to-rural migration of 2.7% of the population from 1970-1973. See U.S. Census, "Mobility of the Population of the United States, March 1970 to March 1973," Current Population Report, P20, #256 (November 1973), Table 1, p. 3 and our discussion in Chapter 5.

Metropolitan-Level Impact

What has been happening within metropolitan areas? Numerous observers have pointed to the declining importance of the central city in both economic and residential terms. As will be discussed below, evidence exists that this decline is closely linked to the rural-urban shifts which have taken place. There are a number of other factors which have served as both necessary conditions and impetus for centrol city decline and suburbanization.

While the continuation of trends in central city decline into the future is not certain, there can be little doubt about the past decline of the central city. For example, less than 50% of employment currently occurs in the central city of a typical metropolitan area.[7] The character of the employment is changing as well. While suburban growth in the major industry groups (retail, wholesale, manufacturing, services) is far higher than in central cities, cities seem to be specializing in services. This is particularly true for older SMSA's (those which qualified as SMSA's before 1900). For young SMSA's (those qualifying after 1930), there seems to be a good bit of central city growth in the manufacturing and service sectors, particularly for SMSA's of over 500,000 population.[8] Central cities do, however, exhibit an ability to compete successfully with suburban areas for a larger share of employment, particularly in manufacturing and service industries, in times of economic growth than in times of contraction.[9]

These trends are important to the subsequent analysis in two respects. First, to the extent that residential location is directly affected by location of workplace, the suburbanization of industry will have an obvious suburbanizing effect on the population. Second, the flight of business from the central city, or, more accurately, failure of business to locate in the central city is thought to exacerbate tax base and fiscal problems, which have their own effect on residential location. We will discuss this in greater detail in a later section.

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[7] R. Ginn, H. J. Brown, et al., The NBER Urban Simulation Model, NBER (New York: 1971), Ch. 2.

[8] David L. Birch, The Economic Future of City and Suburb. CED (New York: 1970), cf. Figs. 1, 4 and 6.

[9] Bennett Harrison, Urban Economic Development, Urban Institute (Washington, D.C.: 1974).

In 1970, SMSA populations outside the central city were greater than those inside.[10] This had been true since the early 1960's and was the outcome of a trend which had been occurring with increasing rate since the 1920's, particularly in the post-1945 era.[11]

In fact, this disparity would be even greater if it were not for annexations by central cities. This source of population growth accounted for over 90% of the growth of central cities in 1960-70.[12] This trend should slow, however, as more and more of the territory around central cities becomes incorporated. Since annexation has been a source of tax base growth for central cities, the slowing of annexation also may accelerate the flight of whites from rising taxes in central cities.

Apart from growth, or lack of growth, as a result of boundary changes of either metropolitan areas or central cities, there are other, more fundamental determinants of suburbanization of the population. We have mentioned above the possible role of the overall suburbanization of industry. Others are: rising affluence; the internal combustion engine and the Federal highway program; Federal tax shelters, both for homeowners and owners of rental properties; FHA/VA encouragement of single-family unit ownership; and ghettoization of blacks within central cities, both as it reflects pure racism and as it works to increase central city tax rates, through "spill-ins" and "spill-overs."

Rising Affluence. The importance of rising real income for suburbanization has been noted by many, including Hoover, Alonzo,[13] and

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[10] Report on National Growth, op. cit., Table 11.

[11] Birch, op. cit., Figure 7B.

[12] Report on National Growth, op. cit., Table 10.

[13] Edgar M. Hoover, "The Evolving Form and Organization of the Metropolis," in Harvey S. Perloff & L. Wingo, Jr. (eds.), Issues in Urban Economics, Resources for the Future, Johns Hopkins Press (Baltimore, Md.: 1968), pp. 270-272; William Alonzo, Location and Land Use: Toward A General Theory of Land Use, Harvard University Press (Cambridge: 1965), pp. 105-109.

Muth.[14] Increased income can be spent for greater living space, newer housing, longer or more expensive commutation, and improved public services, among other things. At least in the recent past, these goods have been associated with suburban location, and rising real income, in conjunction with the other factors mentioned below, can be postulated to promote suburbanization. Of course, neither constant tastes nor continued rising incomes are at all certain in the future. And, as Wheaton[15] has noted, the effect of rising incomes need not necessarily lead to suburban location, since time (for commuting) is then valued at a higher rate. However, since proximity to work or shopping is also associated with negative aspects of the urban environment, such as noise, blight, and industry, rising incomes have tended to facilitate flight to the suburbs.

Changing Transportation Technology. Moses and Williamson[16] show that prior to 1900, the cost of moving goods within cities was high relative to moving people within cities and goods between cities. This resulted in centralized industry and (around transport hubs) trolley commuters, and a fairly compact pattern--"suburbs" were "streetcar suburbs" in close proximity to downtown. The truck then facilitated the decentralization of industry.

The automobile in the post-World War II era has permitted greatly dispersed residential patterns. The Federal Interstate Highway System, begun in the 1950's, has had the additional effect of providing for the automobile a "line-haul" capability into, and easy distribution within, urban areas. Thus, even in the larger metropolitan areas, a person

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[14] Richard F. Muth, Cities and Housing, University of Chicago Press (Chicago: 1969), p. 29.

[15] William C. Wheaton, "Income and Urban Location," Unpublished Ph.D. dissertation, University of Pennsylvania (1972).

[16] Leon F. Moses and H. F. Williamson, Jr., "The Location of Economic Activity in Cities," American Economic Review, Papers: (May 1967), pp. 211-222.

can live a considerable distance from work or other attractions, at low density, and incur travel times and costs which compare favorably with other forms of mass transit which depend on a much more compact service area. This is so because commuters are very sensitive to trip time and the line-haul speed differential which a train, for example, must have in order to offset the mode change and pickup wait time handicaps equals or exceeds foreseeable technology, not to mention the capacity of most existing equipment.[17] The change to the auto has, of course, often been cited as a major impetus for suburbanization in the postwar, pre-energy-crisis era, even though the social costs, in terms of pollution, congestion, and urban disruption, of these cumulative individual decisions may be far from optimal.

Federal Tax Provisions. Tax provisions relating to both owner-occupied units and to income-producing rental units are sometimes blamed for accelerating suburbanization directly through the encouragement of home ownership or indirectly through hastening the deterioration of low-income properties by encouraging their "milking" and rapid resale.

The argument often made with regard to rental units is that accelerated depreciation provisions of the tax laws have accelerated the deterioration of slum properties. They have done this by providing a tax shelter for high-income individuals who hold the property long enough to realize the bulk of the shelter, then sell to another like-minded investor. Such a situation clearly fosters "milking" the

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[17] J. R. Meyer, J. F. Kain, M. Wohl, The Urban Transportation Problem, Harvard University Press (Cambridge, Mass: 1965), pp. 102-106, present this argument.

property and militates against sound management. Sternlieb,[18] however, questions this thesis on the basis of prior studies and his own research, which indicate that a soft slum market and other factors are much more important in slum decline than are instances of the abuse of accelerated depreciation provisions.

Of greater importance, both in terms of amounts of money involved and people affected, is the Federal tax shelter granted homeowners for interest and local property tax payments, as well as the capital gains treatment of land value appreciation. This is a subsidy of a politically very palatable kind, since the money never appears on the U.S. Treasury books as receipt or disbursement. The effect is not small. The mayor of San Jose alleges, for example, that in a recent year in San Jose, California, the total HUD expenditures in the area were less than the capital gains tax break on land value appreciation.[19]

A crude assessment of the magnitude of the subsidy from property tax and capital gains exclusions is presented in Tables 3-5. Table 3 presents various measures of Federal, state, and local effort for community development, housing, and urban renewal. As can be seen, HUD aid to state and local governments for public housing and urban renewal totaled $1.5 billion in 1970. Total Federal aid to state and local governments for community development and housing was about $2.4 billion. The

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[18] George Sternlieb, The Tenement Landlord, Rutgers University Press, (New Brunswick, N.J.: 1966), Chapter 5.

[19] "Statement of Hon. Norman Y. Mineta, Mayor, City of San Jose, California, on Behalf of the U.S. Conference of Mayors and the National League of Cities," in National Growth Policy, Selected Papers Submitted to the Subcommittee on Housing of the Committee on Housing of the Committee on Banking and Currency, House of Representatives, 92nd Congress, 2nd session, U.S. Government Printing Office (Washington, D.C.: 1972), Part I, p. 114.

total expended at all levels of government (excluding duplicate transactions) for both capital and recurring expenses was $5.4 billion.

The Federal government aids homeowners through the tax laws by the deferment of the payment of capital gains tax on the sale of a residence if another home is purchased within one year or built within 18 months. Since the final settlement may be deferred for an extended period, is subject to a sizable exclusion, and may come when the household has little taxable income , this is essentially tantamount to not taxing capital gains, and subsidizing home ownership via-à-vis renting.

In Table 4 is estimated the capital gains for owner-occupied units held for an average length of time. This was done as follows: From census tabulations of median values, compound growth rates from 1960 to 1970 were computed, as was the average years at address for homeowners. This allowed the computation of a rough estimate of capital gains realized from the sale of a house in 1970 for each household moving, and the computation of the capital gains tax foregone at average tax rates.

At the then-current tax rates, this subsidy to home owners consisted of $1.4 billion for the nation as a whole. Interestingly, this is approximately equal to the aid HUD provided state and local governments for public housing and urban renewal (see Table 3). The subsidy to suburban areas of $.8 billion was twice what HUD provided for public housing, and close to what was provided for urban renewal.

This estimate is admittedly very rough, relying as it does on median value and years at address for all houses and households, not these sold or moving. Also the tax rate ignores the progressive nature of taxation. However, the procedure does provide ballpark estimates.

While it is incorrect to assume that a tax rebate of a few hundred dollars every ten years will be sufficient to lure many renters to homeownership,

Table 3

Various Types of Expenditures
for Housing and Community Development: 1970

($ in millions)

Department of HUD: Aid to State and Local Governments	
Low-Rent Public Housing	$ 434.5
Urban Renewal	1,053.4
Total	$1,487.9
Federal Aid for Community Development and Housing to State and Local Governments	$2,432.0
Housing and Urban Renewal (Federal, State, Local - excludes duplicate transactions)	
General Expenditures	$3,189.0
Capital Outlays	2,172.0
Total	$5,361.0

Sources:
HUD: U.S. Bureau of the Census, Statistical Abstracts of the United States: 1972, 93d Edition, Government Printing Office (Washington, D.C.: 1972), Table 656, p. 414.
Federal Aid: Ibid., Table 655, p. 413.
Housing and Urban Renewal, General Expenditures: Ibid., Table 652, p. 411.
Housing and Urban Renewal, Capital Outlays: Ibid., Table 653, p. 411.

Table 4

Estimated Federal Taxes Forgone, 1970, from Capital Gains Exemption on Sale of Residence

	Total U.S.	Inside SMSA's Central City	Ring	Total
Capital Gains Per Unit (Owner-Occupied Units)				
Median Value 1970	$17,000	$16,400	$20,800	
Median Value 1960	11,900	12,300	14,400	
Ratio 1970/1960	1.43	1.33	1.44	
Compound Rate	3.6%	2.9%	3.7%	
Average Tenure				
Years At Address	11.1	11.7	10.1	
Capital Gains	5,563	4,656	6,410	
Income Tax Rate				
Median Family Income - 1970	$10,955	$10,960	$12,753	
Effective Income Tax Rate (Family of Four)	11.94%	11.95%	13.31%	
Federal Tax Forgone ($ in millions) (Owned-Occupied Units)				
Households Moving 1969-March 1970	4,288,403	982,095	1,794,038	2,776,133
Average Tenure (years)	11.1	11.7	10.1	
Capital Gains	$23,856.4	$4,572.6	$11,499.8	$16,072.4
Tax Forgone	1,424.2	273.2	765.3	1,038.5

Sources:

Median Value, 1970: U.S. Bureau of the Census, Census of Housing: 1970, Vol. I, Housing Characteristics for States, Cities, and Counties, Part 1, United States Summary, U.S. Government Printing Office (Washington, D.C.: 1972), Table 31.

Median Value, 1960: U.S. Bureau of the Census, U.S. Census of Housing, 1960, Vol. I, States and Small Areas, Part 1: United States Summary, U.S. Government Printing Office (Washington, D.C.: 1963), Table 2.

Ten-year Compound Rate: $r = [\text{Value (1970)}/\text{Value (1960)}]^{1/10} - 1.0$

Average Years at Address: Census of Housing: 1970, ibid., Table 33.

Capital Gains: $\text{Value (1970)} - [\text{Value (1970)}/(1 + r)^{i}]$, where i = years at address.

(continued)

Table 4 (continued)

Sources (continued):

Median Family Income, 1970: U.S. Bureau of the Census, *Census of Population: 1970, Subject Reports, Final Report PC (2) - 8A, Sources and Structure of Family Income*, U.S. Government Printing Office (Washington, D.C.: 1973), Table 3.

Effective Tax Rate: The tax (including surcharge) paid by a family of four with given median family income, as a per cent of median income.

Households Moving: *Census of Housing: 1970*, *ibid*., Table 33.

Capital Gains: Capital Gains Per Unit times Households Moving.

Tax Forgone: Total Capital Gains x .5 x Tax Rate.

or that the imposition of the tax would have the opposite effect, the commonly quoted price-elasticity of demand for housing of -1.0 or less implies that such rebates will find their way fairly directly into the housing market in the form of increased consumption.

Another tax credit comes from the deduction of property tax payments to state and local governments. The amount of tax foregone if everyone takes this deduction is easy to estimate, since actual property tax collections are published.

In Table 5 is estimated the magnitude of the foregone revenue from allowing homeowners to deduct property tax payments from before-tax income. Although this policy is essentially constitutionally mandated, we are interested in comparing the incentive it provides for home ownership with efforts at ameliorating and guiding urban growth. Some $4.1 billion in subsidy are provided from this source. This is larger than all Federal aid for community development and housing, and all general expenditures or capital outlays for housing and urban renewal at all levels of government. The sum of the capital gains and property tax subsidies is almost as great as the sum of general expenditures and capital outlays at all levels of government.

Table 5

Federal Income Tax Forgone from Property Tax Exclusion: 1970

($ in millions)

Property Tax	Collections	Federal Tax Forgone
State	1,092.	130.4
Local	32,963.	3,935.8
Total	34,054.	4,066.2

Sources:

Collections: U.S. Bureau of the Census, Statistical Abstracts of the United States: 1972, 93d Edition, Government Printing Office (Washington, D.C.: 1972), Table 654, p. 412.

Federal Tax Forgone: Effective 1970 Federal tax rate, including surcharge, for family of four--11.94% of 1970 median family income for U.S. of $10,955--multiplied times collections.

Of course, the same remarks apply to this estimate as did to the capital gains estimate. The analysis is admittedly partial and incomplete. Aaron[20], for example, estimates that credits for mortgage interest, property tax exclusions, and imputed net rent on house equity total $7 billion per year. This does not include the capital gains exclusion, but does include imputed income, which might be hard to tax, although some homeowners may do the accounting in this manner.

Additionally, we do not adequately account for direct and indirect market effects. However, the object is not to provide a definitive statement on tax subsidies, but only to indicate the rough magnitude of the effects.

There is, of course, no control over the use of these subsidies. The tax shelter voucher can be used anywhere in the country, and anywhere in a metropolitan area--in fact, it is worth more in a fast-growing suburban area than in a central city. These policies do not create trends, of course, but do tend to amplify existing trends. A subsidy of a few hundred dollars a year at most to the average homeowner will not cause a radical change in the behavior of any one household, but the cumulative effect of small changes could have a large impact on the market as a whole.

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[20]Henry J. Aaron, Shelter and Subsidies: Who Benefits from Federal Housing Policies?, The Brookings Institution (Washington, D.C.: 1972), Ch. 4.

Federal Mortgage Insurance. This Federal policy has been cited[21] as a major facilitator of suburbanization, which it was. It did this in an indirect but highly powerful way--by removing much of the uncertainty from the home mortgage field. This was done at a relatively small fiscal (and hence political) cost--the cost of administration and covering of bad debts--even though the Federal government is now, as a result, the nation's single largest homeowner. In addition, it explicitly fostered racial segregation from the 1930's until 1950 by the requirement of racially restrictive covenants in mortgages. While the facilitating of home ownership was in itself laudable, the policy was pursued with no coordination of aid to the central cities which were so heavily affected.

Ghettoization of Blacks Within Central Cities. Burton and Garn,[22] among many others, have pointed to the importance of the increasing ghettoization of poverty-area residents (predominantly black) from the rest of the metropolitan population. This single issue has had leverage far beyond the numbers of people involved, and interacts with all of the other factors discussed. Because of the condition of the housing stock, poor and/or black immigrants to metropolitan areas settled in central cities. This had two effects.

One, because of racism on the part of whites, coupled with the American, particularly northern, tendency for residential location to reflect closely the social structure,[23] whites fled to safer territory--i.e., the suburbs. They were of course aided in this by FHA guarantees

[21]Mineta statement, Ibid.

[22]Richard P. Burton and Harvey A. Garn, "The President's Report on National Growth, 1972: a Critique and an Alternative Formulation," in National Growth Policy, op. cit., pp. 647-703.

[23]James M. Beshers, Urban Social Structure. Free Press (New York: 1962) especially Chaps. 5 and 6.

(even the requirement of restrictive covenants before 1950), and encouraged by the home ownership tax shelter and by increasing auto usage and rising incomes.

Two, this very flight, coupled with replacement by people who were less able to pay, strained central city budgets, thus accelerating the flight of whites. And, under the system of "fiscal federalism," central cities often provided services to nonresident workers for which no reimbursement could be obtained, which tended to strain the budgets even further. In the next section we review a study which tends to confirm that these feedback effects are indeed at work.

Systematic Explanations: Macro Level

The remarks in the last section were highly impressionistic and did not attempt to assign weights to the proposed determinants, only to indicate what might be important and that the determinants did not include locally controllable items. In this section we review several attempts at quantification, as a check on our speculations.

On the face of it, suburbanization is an almost trivial result of the expansion of an area's population. Cities can go up or out. If out, suburbanization would result unless the effects of transport costs, agglomeration economies, or whatever other basis one chooses for explaining urban concentrations, are so slight as to permit an extremely scattered development initially. However, in that case, it is not clear that a definable urban concentration would exist.

Clark[24] was perhaps the first investigator to document in a statistical manner for a large number of cities the observation that density declines exponentially. He noted further that the density functions have become flatter through time. This flattening is one index that suburbanization is occurring, for cities could also spread out in a manner which kept the density functions parallel. Changes in this gradient, either between cities or for the same city at two points in time, is then one easily computed index of suburbanization.

Studies by Mills[25] and Muth[26] have documented these changes in greater detail than Clark and have made an attempt at explanation. The model is a very simple one and it is easy to estimate the parameters. It

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[24]Colin Clark, "Urban Population Densities," Journal of the Royal Statistical Society: Series A, 114 (1951), p. 490-496.

[25]Mills, op. cit., Chapter 3.

[26]Muth, op. cit., Part II, passim, especially Chapter 7.

is: $D(u) = C.e^{-\alpha u}$, where D(u) is the population density at distance u from the city center, C is the density at the center, and α is the slope coefficient. Taking the logarithm of both sides yields an equation linear in the parameters. This is the approach taken by Clark and Muth.

Muth drew a sample of 25 tracts for each of 46 U.S. cities from the 1950 census. All but six density gradients (the α's) were statistically significant,[27] and distance alone (the u's) explained about one-half the variance in density among tracts. Muth then attempted to predict the value of this density gradient with a variety of other variables in 36 of the cities. In his most extensive equation,[28] car registrations, black population in the central city, central city dwelling units substandard, and urban area population size measures were negatively related to the gradient, and manufacturing employment in the central city was positively related. This was seen as supporting his hypotheses about the importance of transport costs, employment concentration, tastes, and urban size, as these variables explained about three-fourths of the variance in the estimated density gradient.

Muth's study had the disadvantage of being cross-sectional, for 1950 only. Mills studied fewer cities across time. Using an ingenious method which allowed estimation of the density function parameters from only the area, radius and population of the central city and the population of the metropolitan area, Mills estimated density functions for population and employment in four industry groups for 18 areas at four points in time. He found a consistent flattening through time for all the density functions, and a narrowing of disparities between population and employment. For all four years (1948, 1954, 1958, 1963) the ranking from most to least dispersed was population, manufacturing, retailing, services, wholesaling.

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[27] Prob ($\alpha = 0$) $< .01$

[28] Muth, _op. cit._, Tables 7 and 8, pp. 154-155.

In an effort to test whether suburbanization had been more rapid in the postwar era, he extended the analysis for six of the cities back to 1920, and for four back to 1880. The method was to examine the trend in the exponent to infer suburbanization -- the smaller the exponent the greater the degree of suburbanization.

By averaging the coefficients for all six cities he concluded that the employment sectors were suburbanizing steadily before World War II. He claimed that the same was true of population, and that the "rapid suburbanization in the early postwar years was the result of catching up after the stagnation of the 1930's, rather than of important new forces."[29]

While an explosion of pent-up demand was certainly at work, a closer look at the results shows that very rapid drops for two of the smaller cities (Rochester and Toledo), coupled with his averaging process, distort the overall change from 1920-1930, which was relatively gentle for the other cities examined. This is most easily illustrated graphically.

Figure 1 plots the gradients for the six cities, four from 1880, as well as the six-city average from 1920. Clearly, the variance among the coefficients decreases through time. In the pre-1930 era, the mean of the coefficients is not a particularly good measure of the overall central tendency of the group. While the drop in the density gradient for Toledo from 1920-1930 is much steeper than at any other time and that for Rochester is as steep as the 1940-1948 period, in none of the other four cities is the 1920-1930 decline as large as the postwar (particularly 1948-1958) decline. However, the figure does reveal the rapid declines in density before 1910 for Rochester and before 1900 for Baltimore.

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[29] Mills, op. cit., p. 47 .

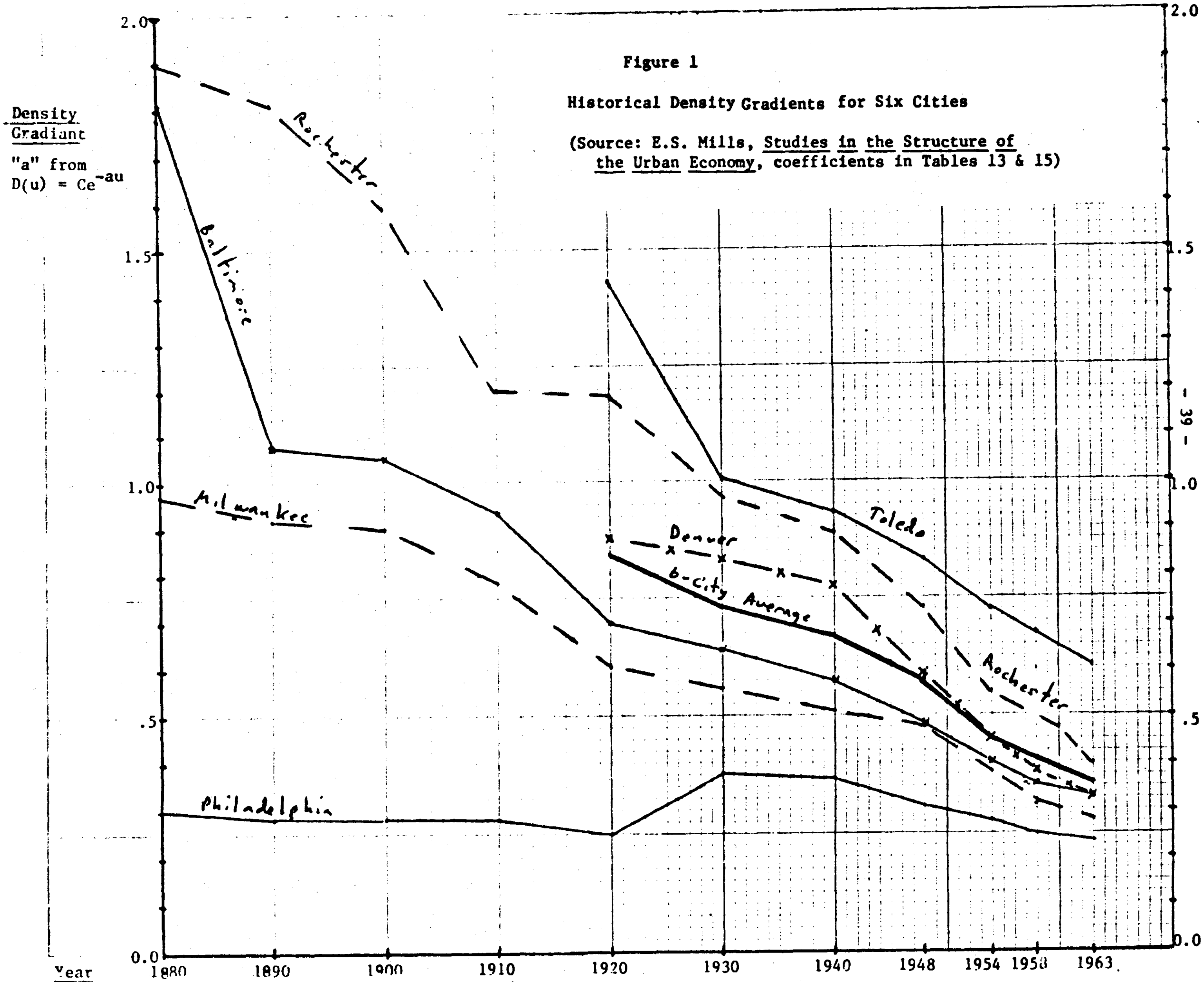

Figure 1

Historical Density Gradients for Six Cities

(Source: E.S. Mills, Studies in the Structure of the Urban Economy, coefficients in Tables 13 & 15)

In an attempt to illustrate the actual changes in a representative function, Figure 2 plots the actual density function for each year for Denver, the city closest to Mills' six-city average. It shows both the flattening of the curve and the lowering of the central city density over time, with the greatest flattening in the 1940-1958 time period.

Mills goes on to formulate a disequilibrium adjustment model based on a distributed lag process with SMSA population, median family income and time as the exogenous variables. This is used to predict changes in both central city density (C) and the gradient (α). This formulation explained over 90% of the variance of changes in the population density of the 18 cities from 1948-1963. However, for α, only the lagged value of α is statistically significant[30] (and positively related), while for C, both lagged C and SMSA population are signficant (and positively related). This conforms to what would be expected: a large amount of autocorrelation in such a slowly changing phenomenon as urban density. In addition, large cities should have higher central city density than small ones, extending further up and out.

Mills then goes on to discuss the statistically insignificant coefficients for the gradient. The coefficient for SMSA population is negative as is that for SMSA median income, while the coefficient for time is positive.[31] Mills concludes that, "If the signs of the coefficient reported in the tables are accepted, they have the striking implication that the cause of the historical flattening of population density functions has been the growth of urban population and income rather than the passage of time or whatever it stands for."[32]

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[30] Note, however, that the use of ordinary least squares with small samples in the presence of autocorrelated errors may yield estimates of α which are too low. See Mahlon R. Straszheim, "Econometric Issues in Interpreting Mills' Estimates of Urban Density Gradients," <u>Journal of Urban Economics</u>:1 (1974), pp. 445-448.

[31] Population: $\text{Prob}(\beta_1 = 0) > .5$; Income: $\text{Prob}(\beta_2 = 0) > .2$; Time: $\text{Prob}(\beta_3 = 0) \approx .1$.

[32] Mills, <u>op. cit</u>., p. 56.

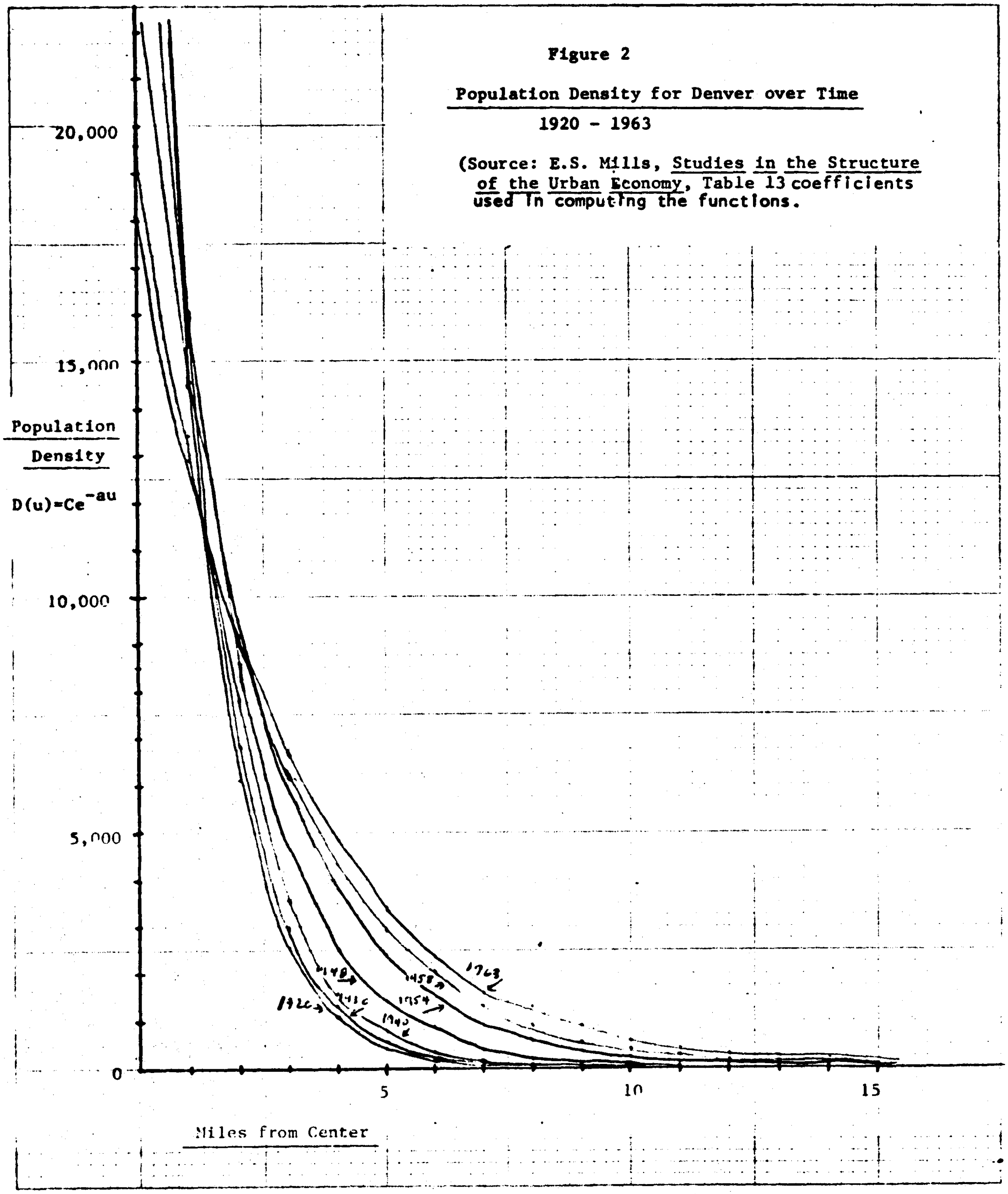

Figure 2

Population Density for Denver over Time

1920 - 1963

(Source: E.S. Mills, Studies in the Structure of the Urban Economy, Table 13 coefficients used in computing the functions.

A troublesome problem with Mills' conclusions is the statistical significance of the population and income parameters, which are quite low by anyone's standards. Mills attributes greater significance to these two than he does to time, although both together probably explain less of the variance of the gradient α than does time. This may not mean that these variables are unimportant, since this seems to be a situation in which collinearity is a problem. Since the R^2 is high, and income has been found to be positively associated with SMSA size,[33] the standard errors of the coefficient estimates would be expected to be high, and t-values low. The separate effects of population and income cannot be estimated with single-equation methods if this is the case.

It may, however, be quite important to correctly specify and disentangle the separate contributions of population and income. Analyzing a micro-economic formulation of the same question, Alonzo[34] argues that without income rise, there is no "suburbanization" (expansion of the margin of settlement and lowered densities) simply from an increase in population. An increase in only population will result in higher densities and land prices through increases in the demand for land. Muth[35] modifies this conclusion by noting that if the elasticity of substitution of land for nonland factors is less than unity, then output will be more responsive on the fringe. Alonzo's rule will thus not always hold. That is, accelerated housing supply response on the periphery may reduce density even without income rise, if demand for housing increases. Thus, a more complicated model would clearly seem to be called for.

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[33]William Alonzo, "The Economics of Urban Size," Institute of Urban and Regional Development, University of California, Berkeley (November 1970), Working Paper #138.

[34]Alonzo, Location and Land Use, op. cit., pp. 105-116.

[35]Muth, op. cit., pp. 314-316.

The point which clearly emerges from Mills' results is the importance of the autoregressive component. This importance could stem from one or both of two possibilities.

One is that the autocorrelation is "real" in the sense that inertia plays a large role in the growth of cities. That is, urban processes have large time constants, and once movement of a certain sort is initiated, it is not easily or quickly reversed.

The other reason the autoregressive component is so strong may be that important explanatory variables have been omitted or other errors of specification enter in. Since economies of scale, acting through size of income, may be present, additive terms for these variables may not be appropriate. The distribution of income in a city would also be expected to have an effect on the density gradient. In Muth's investigation cited above, the percentage black in the central city had a decentralizing effect. Perhaps cities with a smaller per capita income variance would be more centralized. Finally, as far as income is concerned, transportation is a good, and is purchased with income. Thus, it is not at all clear that time is the only proxy for a changing transportation effect. Income may well be another. Time, as Mills points out, may also index other changes, such as high-rise building technology, which would counter the hypothesized transportation effect in time. It might be preferable to include these variables directly, rather than time, which is merely a subscript of change.

A step in the direction of a more adequately-specified model has been taken by Bradford and Kelejian.[36] They attempt to predict changes in a transformation of the density gradient for separate income classes for a sample of U.S. cities. Their estimation technique is two-stage least

[36] David Bradford and Harry H. Kelejian, "An Econometric Model of the Flight to the Suburbs," Journal of Political Economy: 81-3 (1973), 566-589.

squares which allows them to include as predictor variables in one equation the dependent variable in another equation (e.g., concentration of poor families in the central city). They also include fiscal and housing stock variables.

Their results clearly indicated that a lagged concentration of poor families in the central city, as well as a high median income and low fiscal surplus in the central city promoted a higher suburbanization of the middle class. A higher balance of older housing in the suburbs and lower central city fiscal surplus promoted increased concentrations of poor families in the suburbs. Racial composition was insignificant, although this could be due to collinearity with poverty.

Their results indicate a feedback effect of the flight of the middle classes from the central city, and the apparently self-defeating aspect of a central city's attempt to stem this flight with internally-funded solutions, similar to the observation of Forrester.

Systematic Explanations: Micro Level

The studies described in the previous section have the potentially serious weakness of attempting to infer the determinants of individual actions from the examination of such a gross phenomenon as a density gradient. For example, Birch, et al., show how a negative exponential density function can be generated simply by households in different decades having an increasing commuting radius over time from the central business district. In this view, the epochs in which growth takes place are of primary importance in determining the shape of the density function. Their central point is that ". . . one cannot infer causality at the margin over time from cross-sectional distributions at a point in time. The cross-section is, in general, the integral over time and over space of actions taken during an extended period, and may or may not shed light on the decision rules being followed at any instant."[37]

In Chapter 4 we review the conditions under which one can safely impute determinants of individual behavior from aggregate phenomena. Suffice it to say that they are quite restrictive, and investigations at a disaggregated level should be attempted wherever possible.

Insofar as individual household behavior has been examined, the tradition which has been followed in economics has received much attention. The early micro-economic model of Alonzo[38] implied that distance from work was a positive function of income and that the rich would settle on the periphery, under certain assumptions about behavior.

The approach assumes a monocentric city, with all employment and goods located there, and otherwise a "featureless plain" with

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[37] David L. Birch, R. Atkinson, S. Sandstrom, L. Stack, The New Haven Laboratory: A Test-bed for Planning, Lexington Books, D. C. Heath (Lexington, Mass.: 1974), pp. 176-182.

[38] William Alonzo, Location and Land Use, op. cit.

respect to transportation costs. There are no institutional or other constraints to purchasing land, and one individual is capable of knowing the price of land at every point but cannot affect the price by his decisions. Transportation costs are proportional to distance and not a function of income. All households have the same tastes and the same number of trips to the core. Each individual household seeks to maximize its utility, subject to its budget constraints, by manipulating space consumed, distance from the core and consumption of other goods.

An extension of this approach by Beckmann,[39] which imposed the further constraint that the overall distribution of income in the region be a Pareto distribution (or inverse power function), reached the same conclusion--that the wealthy would settle on the fringe and the poor concentrate in the center.

The most extensive examination of this model concluded that income must rise with increasing distance from the center for all individual households to achieve a maximum of utility.[40] That is, under the assumptions of the model, if transportation costs are positive, the maximization of utility for each household (the objective of this sort of analysis) implies, and is implied by, richer households living farther from the core at decreasing residential density and decreasing land rent per acre. The author cautions, however, that "The analysis, difficult even with the simple assumptions suggested by Beckmann, will likely become very arduous in the general case so that numerical specific analyses could be preferred: realism may exclude generality."[41]

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[39] Martin J. Beckmann, "On the Distribution of Urban Rent and Residential Density," Journal of Economic Theory: 1 (1969), pp. 60-67; and Jerome K. Delson, "Correction on the Boundary Conditions in Beckmann's Model of Urban Rent and Residential Density," JET: 2 (1970), pp. 314-318.

[40] Aldo Montesano, "A Restatement of Beckmann's Model on the Distribution of Urban Rent and Residential Density," JET: 4 (1972), pp. 329-354.

[41] Ibid., p. 354.

A theoretical and empirical study by Wheaton yielded some interesting conclusions which both extended the theory and showed why it fails to describe adequately actual location behavior of individuals within an actual system. By including nonwork time in the consumer's utility function, Wheaton was able to include the effect of income in determining the costs of commuting. Whether income rise led to a more distant or a more central location was thus an empirical question. In addition, the possibility of tastes varying by household type was included.

A general form for the utility function was chosen and estimated for seven selected household types (as subset of the 128 possible combinations of four income classes, eight age-family size classes, two race and two occupation categories) from San Francisco traffic survey data. The results of the estimation[42] indicated that time was most highly valued by all groups and land least highly valued for all but large families.

A simulation was conducted, using only land, housing and distance to work as variables, to see what the effect of these groups bidding against each other would be, other things, such as externalities or public services, being held equal. The results were striking in that the city center was inhabited by the wealthy, followed by the young, followed by middle-aged middle-income families and old families, followed by middle-aged low-income families and large families. Significantly, "the income location pattern . . . was exactly the opposite of that found in the Bay Area today . . . [and] . . . households of larger size . . .

[42] William C. Wheaton, "Income and Urban Location," op. cit., pp. 124-128.

located further away--on larger lots . . . without externalities or government services as a consideration in locational choice."[43]

Wheaton's study, the main serious attempt to empirically apply Alonzo's theory, is significant in that it points up the importance of other factors in determining the actually-observed locational patterns in metropolitan areas today. Among these are externalities and clustering, a relatively fixed housing stock, and time dependencies in the system. All of these introduce the quadratic nature of preferences which is ignored by the Alonzo model and its extensions.

It seems undeniably true that various forms of nonresidential land use have positive (e.g., parks) or negative (e.g., heavy industry) effects on location decisions of households. Theoretical or empirical treatments of these effects, however, are rare.

Stull[44] has examined both the theoretical and empirical (for Boston in 1960) aspects of the case of industrial and commercial uses (assumed undesirable) and their effect on land values in an urban area. In particular, for single family dwelling units, he found quadratic patterns of land value change associated with proximity to various nonresidential uses. Other studies have observed this effect at a smaller scale as well.[45]

Other residential uses can also affect locational decisions. Numerous authors have discussed the impact of race and ethnicity--this

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[43] Ibid., pp. 153-154.

[44] William J. Stull, "An Essay on Externalities, Property Values, and Urban Zoning," Unpublished Ph.D. dissertation, M.I.T. Department of Economics (Cambridge, Mass.: 1972).

[45] See, for example, Robert E. Couglin and James Fritz, "Land Values and Environmental Characteristics in the Rural-Urban Fringe," Regional Science Research Institute Discussion Paper #45 (Philadelphia, Pa.: 1971).

was also treated in previous sections. Numerous other studies have documented the effect of clustering by occupational status.[46] There is evidence that clustering is not simply attributable to differences in earning power by occupation, but reflects the effect of different tastes and life styles. The easing of transportation constraints seems to intensify this tendency for occupational clustering.[47]

The existence of a fixed, slowly-varying stock of housing is of course obvious. However theoretical treatments of location tend to ignore this aspect in a concentration on long-run equilibrium analysis. Additionally, the simultaneous nature of household location (demand) factors and construction, renovation, and "filtering" (supply) responses has been largely ignored until recently.[48]

The time dependence of all of the above factors is a final aspect of location which is crucial, but often ignored. This introduces a term which is quadratic in time as well as space. Since the stock of housing is relatively fixed, and population concentrations often slowly varying, decisions of movers, as well as the overall urban form, at any one point in time are quite different from what they would be if everyone were picked up and dropped back down in their most preferred arrangement.

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[46] See, for example, William L. Clarke, "Intra-Metropolitan Migration and Town Characteristics," Unpublished M.C.P. Thesis, M.I.T. Department of City Planning (1967) or Peter M. Allaman, "Household Location and Migration Within the Boston Metropolitan Region," Unpublished M.C.P. Thesis, M.I.T. Department of City Planning (1967), and the references cited there. Most of this is at the aggregate level, however.

[47] Allaman, op. cit., p. 53.

[48] Exceptions are: Muth, Cities and Housing, op. cit. ; Ginn, et al., The NBER.. Model, op. cit.,; and Katharine Bradbury, R. Engle, O. Irvine, and J. Rothenberg, "Simultaneous Estimation of the Supply and Demand for Household Location in a Multizoned Metropolitan Area," Paper presented at Econometric Society meetings, December, 1974.

Studies of individual households[49] have revealed the complexity of the location decision. A study by Silver documented the heterogeneity of the housing bundle and individual motives, and revealed the importance of life cycle, previous neighborhood and tenure effects. A survey by Butler and Kaiser revealed the importance of race, income, suburban orientation and dwelling unit type in residential choice, and stressed the weakness of policy tools at the local level to influence location.

The model[50] employed to generate the inputs for the study reported in later chapters does include a number of the features missing from micro-economic formulations. Since this model is described in greater detail in Chapter 4, suffice it to say here that it simulates, from year to year, the location of households based on the social class and ethnic composition of census tracts, as well as their growth and change. There is simultaneous determination with the housing stock, as well.

The above brief review was intended to emphasize two points. One is the complexity of location behavior and the necessity for even a predictive model to incorporate a very wide-ranging set of determinants. The other is a theme we will treat in somewhat greater detail below — namely, the lack of a crucial role for government services in influencing household location.

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[49] Irving Silver, "A Study of the Demand for Housing in a Metropolitan Area," Ph.D. dissertation, M.I.T. Department of City and Regional Planning (Cambridge, Mass.: 1969); and Edgar W. Butler and Edward J. Kaiser, "Prediction of Residential Movement and Spatial Allocation," Urban Affairs Quarterly: 6, #4 (June, 1971), 477-494.

[50] Birch, et al., The New Haven Model, op. cit.

Public Sector Impact on Location

Some have attributed an important role to local municipalities in the influencing of household location decisions. The "Tiebout hypothesis"[51] postulates that consumers "shop around" among communities to find the mix of services and tax rate that best suits them. In this view, there should be a "capitalization of benefits" reflected in land values, i.e., higher levels of public services should raise land values, but higher taxes should lower land values.

A study by Oates[52] supported this hypothesis. He regressed land values in 53 New Jersey communities on a set of determinants, including the tax rate, educational expenditures, demographic and other variables. He found that land values were negatively related to the tax rate and positively related to educational expenditures. Thus, there was a certain amount of capitalization of benefits.

In a study of Boston communities, Ellickson[53] attempted to demonstrate the importance of the local public sector by attempting a statistical explanation of net population density, without using public sector variables, then examining the errors for systematic patterns defined by local political boundaries. Through this and other methods he concluded that intercommunity inequality in income was significant, implying the interdependency of location and public service levels.

[51] Charles M. Tiebout, "A Pure Theory of Local Expenditures," pp. 513-522 in Mathew Edel and Jerome Rothenberg, Readings in Urban Economics, Macmillan (New York: 1972).

[52] Wallace E. Oates, "The Effects of Property Taxation and Local Public Spending on Property Values: An Empirical Study of Tax Capitalization and the Tiebout Hypothesis," Journal of Political Economy: 77 (1969), 957-971.

[53] Bryan C. Ellickson, "Metropolitan Residential Location and the Local Public Sector," Unpublished Ph.D. dissertation, M.I.T. Department of Economics (1970).

A recent study[54] which estimated structural demand equations in relative-price terms for communities in the Boston SMSA found similar results to Oates. That is, changes in relative prices were negatively related to pupil-teacher ratio and tax rate changes, and positively related to amount of recreational land in the town. While the coefficients had the expected signs, their statistical significance was low. The supply equations did show the inhibitory effect of minimum lot size zoning and the encouraging effect of sewers on construction, however, again, not always with conventional statistical significance.

Other studies have not found convincing evidence in favor of the hypothesis, or have found it to apply selectively. Orr,[55], for example, found only educational and recreational expenditures to be related to gross density, and this only for higher valued homes. Bloom, et al.,[56] in their study of 81 cities and towns in eastern Massachusetts from 1960-70 found no support for the hypothesis that change in school-aged children per household was positively related to school expenditures per pupil, an implication of the Tiebout hypothesis. Contrary to expectation, change in median income was found to be weakly, but negatively, related to expenditure changes. A capitalization of benefits into housing values and rents was found, in consonance with other studies. However, the inmigration of families did not appear to be affected significantly by expenditures.

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[54]Katharine Bradbury, R. Engle, O. Irvine, and J. Rothenberg, "Simultaneous Estimation of the Supply and Demand for Household Location in a Multizoned Metropolitan Area," op. cit., Table 1.

[55]Urban Land Research Analysts Corporation, The Determination of Urban Land Use and Land Values (Lexington, Mass.: 1967), based upon Larry L. Orr, "Municipal Governmental Policy and the Location of Population and Industry in a Metropolitan Area: An Econometric Study," Ph.D. dissertation, M.I.T. Department of Economics (1967).

[56]H. S. Bloom, et al., "The Public Expenditure Model," pp. 87-123, Appendix, Year Two, Carl F. Steinitz and Peter F. Rogers, "The Interaction Between Urbanization and Land: Quality and Quantity in Environmental Planning and Design," Report to NSF, Research Applied to National Needs, published by Harvard University Graduate School of Design, Landscape Architecture Research Office (Cambridge, Mass.: 1973).

On the whole, the evidence is slight in support of a major role for public service level as a strong determinant of location, although effects have been found. In addition, with the exception of the Bradbury, *et al*. study, the above-mentioned studies were all cross-sectional studies of census tract or town data, which further qualifies the results.

While government services may not strongly affect precise locational decisions, several authors have commented that the structure of local government and taxation policies tend to generally encourage suburbanization. Rothenberg[57] argues that the Balkanization of metropolitan government results in suburbanization being carried too far. Another study[58] concludes that no property tax policy *per se* will correct the tendency for peripheral land to be brought into development prematurely by speculative overdevelopment due to the lagged nature of the response of developers to demand and the decentralization of development decisions.

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[57] Jerome Rothenberg, "Local Decentralization and the Theory of Optimal Government," Edel and Rothenberg, *op. cit*., pp. 545-568.

[58] Urban Land Research Analysts Corporation, *Some Relevant Considerations for Metropolitan Fiscal Policy* (Lexington, Mass.: 1970), Chap. 5.

Summary

This chapter has attempted to establish, on the basis of the available evidence, the proposition that the suburbanization of the population has been to a large extent outside the control of the local municipality. It begins by noting the importance of shifts of the population from rural areas to central cities, which has acted as a driving force for other processes within metropolitan areas. Rising affluence and changing transportation technology have facilitated massive shifts. Federal tax provisions provide subsidies for home ownership equal in magnitude to governmental expenditures to combat the "urban crisis," and are uncontrollable in their effects. Federal mortgage insurance has also facilitated suburbanization in an indirect but powerful way, by removing much of the uncertainty from the home mortgage field. The concentration of blacks and the poor in central cities has had an accelerating influence on the tendency for suburbanization.

Systematic explanations at either the macro or micro levels are scarce, but those which do exist do not lend credence to the idea that the massive shifts outward can be arrested or reversed, particularly in the decade ahead.

Those studies which have included local public sector variables in explanations of location are mixed in their findings. At best, the actions of the local municipality seem to have weak effects with fairly long lags, although the examination of the lag structure is hampered by the paucity of time-series data. School expenditures and tax rates are cited most frequently as having an observable locational effect.

As will be discussed in Chapter 5, it has been shown that there are wide disparities in taxation and spending patterns within parts of metropolitan areas. Total tax rates are lower in the suburbs, but the share of these taxes going for schools, as well as the expenditures per pupil, are higher.

Suburban communities are thus in an awkward position either way. If taxes and expenditures have little to do with suburbanization, there is little a suburban municipality can do to stem immigration. If there are fiscal determinants of suburbanization, the very actions which suburban communities are taking will induce growth. Thus, the option of manipulating the trends with the provision of local public services seems limited indeed.

This leaves the possibility for controlling growth resting with that other set of local tools -- zoning and subdivision regulation. While controlling growth, per se, through arbitrary exclusionary policies is not legally acceptable, such control may still be achieved if the policies serve some other purpose as well. There is no question that local policies can slow growth by simply raising the cost of building to "noncompetitive levels. It does seem that certain communities have been able to arrest growth by these means. However, if all suburban communities were to simultaneously and vigorously attempt to block growth, the effect on price would probably be greater than that on growth. Another distinct possibility is that the pressures for development would force a relaxation of the policies in one or more localities.

Moreover, as long as the changes are gradual, a particular community may not realize what is occuring in time to take corrective action. Acceptable families may move in for some time before a new school is required. In fact, it is possible that growth itself may mask the potential ill effects. These are topics we will pursue in the next chapter.

Finally, it is not at all clear that the trends taking place today will slow suburbanization. While fertility is falling families with children are still moving into the suburbs. The effect of energy shortages on location is unclear. The decentralization of blacks may involve the relatively affluent, and exacerbate central city fiscal difficulties. On the other hand, a slackening of the rise in real income or changing real estate tax policies may act to slow the rate of suburbanization. While the models and techniques available are not sufficiently well developed to answer these questions, it seems safe to say that a dramatic reversal in the next 10-15 years is unlikely.

This chapter thus ends with the negative conclusion that there is little which a suburban municipality can do to directly influence the pressures put upon it by secular trends, individual decisions, and governmental structure. Short of a metropolitan combination of governments, which seems highly unlikely in most regions, the best response a municipality can hope to make is to anticipate trends and plan for them. Even if local communities have considerable control, projection and planning would still be required to best anticipate, control, and accommodate whatever growth is allowed, so the utility of the following does not wholln rest on the above argument. One's attention then shifts to the possibility of projecting growth and the effects it will have.

Chapter 3

Considerations in Constructing Predictive Tools

With so many of the determinants of suburban growth outside local control, what are the options available to a town? One option is to proceed on an ad hoc basis, employing one's feeling for the local situation to design short-run solutions to problems as they arise. If the long-term trends are stable, this may not be a bad procedure. However, if the mix of demands (e.g., the school population composition) is changing or if there are lags in the relationships one is employing, the effects of policy may be "non-intuitive" or at least impose a mental computational requirement which is burdensome.

The desirability of a more systematic and comprehensive approach is apparent. One possibility is to develop an increased ability to forecast the growth that will occur in terms which are useful to the local policy makers, the fiscal implications of this growth, and a method of trying alternative scenarios to observe their impact. An extension of this is to establish a method of output measurement, a cost and benefit measurement capability, and a medium for making trade-offs among program elements. We might term these forecasting and program budgeting capabilities, respectively.

We have chosen to concentrate on the question of how to provide a forecasting capability, and what criteria should be employed in its design. We have done this for two reasons. First, for planning purposes, the forecasting function must be performed prior to the program budgeting function. While it is true that program budgeting can be employed for the purpose of solving current resource allocation questions, the possibility of planning has long since passed. And for future programs, one must first provide meaningful estimates, or preferably bounds, for program elements so that resource allocation questions can be addressed.

The second reason we have concentrated on forecasting is the importance of external economic, demographic, and social forces in determining the demand for town services, and the costs of supplying them. We develop this theme in greater detail in the next section. Suffice it to say now that if one can safely assume that budget-line items are highly responsive to external demands for service, and it is possible to consistently forecast demands, then the budget forecasting problem can be solved in a straightforward manner. However, the above assumptions cannot always be made, and an attempt to clarify the conditions under which they can be made is desirable.

The following sections of this chapter discuss our view of the budgeting process, alluded to in the preceding paragraph, then put forth a set of desiderata for budget prediction and analysis, and discuss a few past studies in light of the criteria.

A View of the Budgeting Process

The question of what are the influences determining town budgets, and hence, what modeling strategies are appropriate, has arisen frequently. Crecine,[1] perhaps the first to systematically address the question, stated the trichotomy of views of the budgeting process as: 1) an optimizing process; 2) an internal bureaucratic process; and 3) an externally-determined event.

It is not clear that Crecine's first category describes the budgeting process in the same terms as the other two. Whether or not budgets are determined by totally internal bureaucratic processes or by external events, in principle optimization could be attempted -- it is not a separate "approach" as such. We do, however, agree with Crecine that optimization often requires too much information for a decision to be made, and is infeasible in all but simple applications. In addition, its normative slant may be inappropriate in a political setting, where efficient resource utilization is often of secondary importance.

On the other hand, the question of whether budgets are determined by forces predominantly internal to the organization (the "intra-organizational" view -- Crecine's second category) or by those predominantly external to the organization (the "environmental" view -- Crecine's third category) has profound implications for the choice of a modeling approach. Before proceeding to outline our own approach, it is well to describe the two views more specifically.

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[1] John P. Crecine, Governmental Problem Solving: A Computer Simulation of Municipal Budgeting, Rand-McNally & Co. (Chicago: 1969), Chapter II, *passim*. This book is based on his 1966 Ph.D. dissertation at the Carnegie Institute of Technology.

Whitelaw has produced an extensive review of the two views and summarizes the intra-organizational approach as follows:

> Within the framework of organization theory, the municipal budgetary process is viewed in terms of an internally negotiated, problem-solving sequence in an organizational environment. . . (with emphasis on). . .the phenomena of bureaucracy, conflict among organizational subunits, coordination of departmental activities, and problems of the administrator dealing with the organization.[2]

In contrast, he summarizes the externally-determined, "environmental," view as follows:

> . . .economists, political scientists and sociologists tend to view the municipal budgetary process as being determined by environmental, economic, demographic, political, and social forces. In general, the municipal decision-maker is assumed, implicitly or explicitly, to be at least moderately rational and to be motivated to satisfy the needs and/or desires of the citizens of the municipality.[3]

Further reflection suggests, however, that rather than being competing views, each is descriptive of particular situations. Clearly, all budget determination is an "internally-negotiated problem-solving sequence," but, under circumstances which it is possible to identify, these dynamics may be ignored for the purposes of forecasting, without a loss of predictive accuracy. Under other circumstances, particularly where resource constraints are severely binding, a reshuffling of budgetary priorities will cause internal organizational dynamics to assume a much larger role, and will necessitate a different modeling strategy.

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[2] William Edward Whitelaw, "An Econometric Analysis of a Municipal Budgetary Process Based on Time-Series Data," unpublished Ph.D. dissertation, M.I.T. Dept. of Economics, 1968.

[3] Ibid, pp. 4-5.

It is instructive to present the simplest formulation of an externally-determined system first, then elaborate it to show how intra-organizational considerations -- which essentially involve a reordering of priorities for spending -- come into play. This will happen when the tax rate is constrained in one or more ways.

The simplest possible model would involve at least the following:

Expenditures to service the population	(S_t);
Nonproperty tax revenues from local fees, and state and federal sources	(N_t);
Taxable property	(T_t);
Tax rate	(r_t);
Exogenous determinants of the above	(X_{it});
Fixed coefficients	(β_i).

All quantities are indexed at time t. The exogenous determinants might be numerous, in which case the X's and β's would be vectors.

Expenditures, nonproperty tax revenues, and taxable property relationships are determined exogenously and the tax rate is simply the difference of expenditures minus revenues over the tax base. This chooses that tax rate which balances the budget. This would be expressed algebraically as follows:

$$S_t = X_{1t} \cdot \beta_1 \qquad \text{(Expenditures)}$$

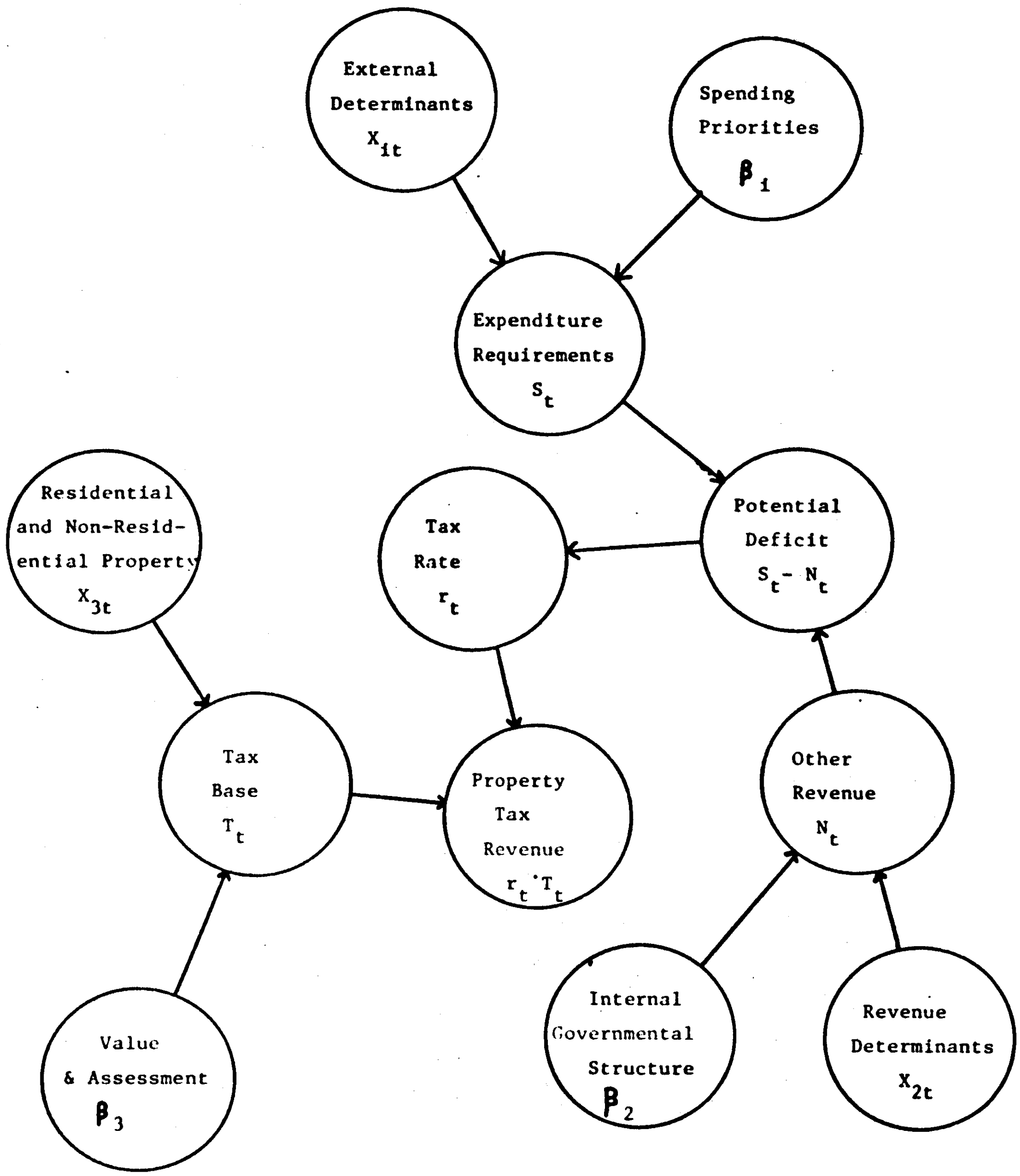
$$N_t = X_{2t} \cdot \beta_2 \qquad \text{(Other revenue)}$$

$$T_t = X_{3t} \cdot \beta_3 \qquad \text{(Tax base)}$$

$$r_t = \frac{S_t - N_t}{T_t} \qquad \text{(Tax rate)}$$

Figure 1

Externally-Determined Balanced Budget



This structure is illustrated graphically in Figure 1. If this seems trivially obvious, studies of "fiscal capacity" have missed this point at times. For example, a study by Aiken[4] regressed tax revenues $(T_t . r_t)$ on various demand and tax base variables without commenting on the reduced-form nature of the estimate or the possibility of simultaneous equation bias.

There are, of course, numerous other influences at work, among them the composition of the community -- affecting both priorities for spending and willingness to be taxed -- as well as debt limits and the effect of potential deficits on priorities for spending and intergovernmental transfers.

These complications introduce variable coefficients and simultaneous determination which greatly complicate the model. We illustrate it graphically in Figure 2 and discuss it below. However, we do not present it algebraically, since it would involve a great deal of notation which is not used later on.

The composition of the community is important to the budgeting process in ways other than its impact on the demand for services. One is its contribution to the residential tax base and a preference for various types of non-residential tax base. These effects are obvious, and we will not discuss them further.

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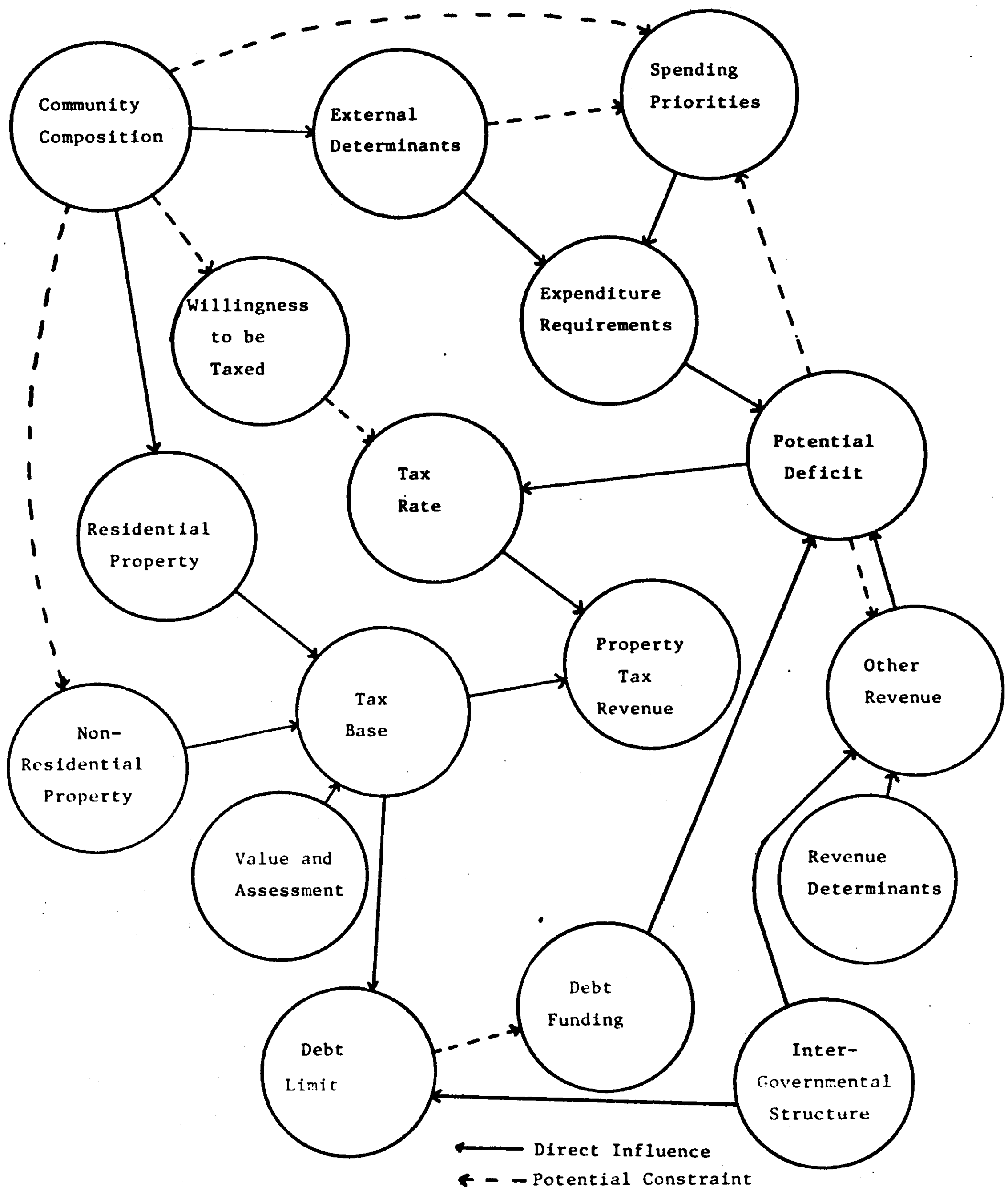
[4] John S. Aiken, "Fiscal Capacity and the Estimation Method of the Advisory Commission on Intergovernmental Relations," National Tax Journal, 26, #2 (June 1973), pp. 575-91.

Figure 2

Potential Budget Constraints



The other two influences of community composition on budgeting are intertwined, but it is worth attempting to make a distinction. One influence is the varying willingness to be taxed. The other is the impact on spending priorities.

There may be a limit on acceptable amounts of taxation -- that is, the tax rate may have an upper bound which, however, varies by the composition of the community. "Taxpayers' revolts"[5] seem to attest to this and "fiscal capacity" studies attempt to quantify it. Alternatively, there may be a limit on the amount of change in any one year which the tax rate may have -- politicians seem to worry about this. What is not clear is whether this is an absolute limit, or whether the revolts or capacity apply to a certain set of spending priorities, which may vary.

There is some work which shows the importance of the class composition of a community for spending priorities. Dobriner[6] characterizes the contrasting attitudes of the working class and upper middle class toward educational expenditures. The working class, in this view, opposes "frills" and supports a 3-R's approach to educational services -- the provision of basic services -- and the holding in check of the tax rate. The upper middle class, in contrast, supports smaller classes, increased building and the introduction of new techniques. In addition, upper middle class persons are seen by Banfield and Wilson[7] as more "public regarding" -- that is more willing to support services from which they themselves do not directly benefit.

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[5] See, e.g., Francis Keppel, "The Cost-Revenue Squeeze," in Financing Public Schools, Federal Reserve Bank of Boston (Boston: 1972).

[6] William M. Dobriner, Class in Suburbia, Prentice-Hall (Englewood Cliffs, N.J.: 1963), pp. 113-126.

[7] James Q. Wilson and Edward C. Banfield, "Public-Regardingness as a Value Premise in Voting Behavior," American Political Science Review: 58, #4 (Dec., 1964), pp. 876-887.

Thus, a potential deficit could affect the tax rate by altering spending priorities, resulting in lowered expenditures, if a population's willingness to be taxed further were exceeded in some way.

Also, the state of the external world, expressed through demand, can affect the ordering of priorities within a budget. Steiner,[8] in his simplified, but very interesting paradigm of national Congressional choice, allows choice between defense (D), stability (S), and redistribution (R). In wartime, Congress gives defense priority over the other two, between which it has no preference (D→ S; D→ R). In a cold war situation, Congressional choices run from stability to redistribution (S→ D→ R). In a peacetime employment situation, stability is preferred to defense or redistribution (S→ D; S→ R).

There seems to be an analogue at the local level, although municipalities do not wage war. Education, public safety, welfare, and similar functions compete for funds. An increase in transients or drug abuse might shift priorities toward public safety and welfare. Increased rural-urban migration might shift it toward welfare and remedial education. The list could be multiplied, the principle being that a shift in the demand for a particular service may, if it is great enough, cause a restructuring of priorities.

It is possible to observe these effects. As was pointed out in the last chapter, fiscal disparities in expenditure levels, for example education, exist within metropolitan areas. At least in part, these disparities

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[8] Peter O. Steiner, Public Expenditure Budgeting, Studies of Government Finance, The Brookings Institution (Washington, D.C.: 1969), pp. 67-70.

arise from items such as welfare services, which have a heavier incidence in central cities than in suburbs. If a commitment to providing a certain service exists, and the demand for that service greatly escalates, then, with a budget constraint, this would cause a restructuring of priorities.

There are two other features of Figure 2 which distinguish it from Figure 1. One is the possibility for potential deficits to feed back to higher levels of government if the source of the deficit can call forth supplementary grants. The other is the capability for debt financing, and the possibility for a state-imposed debt limit to be exceeded.

The overall flows are as follows. Community composition and perhaps changing demands determine priorities. Priorities in conjunction with demands determine a possible schedule of expenditures.

The revenue side is composed of property tax revenue, debt, and revenue from external sources. The external revenue is determined by intergovernmental structure. Higher levels of government also determine acceptable debt limits. The tax base is affected directly by types of residential uses and types of non-residential uses, both of which may be affected by the wishes of the community for certain types of development.

A potential deficit is generated by the difference between potential expenditures and external nonproperty-tax sources of revenue, This is mediated through the tax rate. If there are constraints on the tax rate due to its level approaching or exceeding what the community will support, several things could happen. Expenditures would have to be cut back. If not an across-the-board cut, attempting to retain a "fair share" for each function, then the dynamics of negotiation, etc., emphasized by the intra-organizational theorists, would come strongly into play to reorder priorities and shares of the "pie." If the inter-governmental structure provides aid on the basis of need and effort, then a potential deficit might also raise the amount of external revenue coming in.

The tax rate is thus subject to simultaneous determination with revenues and expenditures. Whether or not expenditures will closely follow demands and whether the relationships will be stable over time is determined by various potential constraints -- limits on taxation and debt limits -- not being exceeded, by stability in the determinants of demand, and stability in community composition.

When priorities for spending are being shifted, then it can be rightly said that "conflict among organizational subunits, coordination of departmental activities" etc. -- intra-organizational determinants -- will have an important role, and one which the model cannot safely omit. However, if the constraints are not exceeded or if the community composition is stable, external demands would be expected to be consistently met. In such a case, the assumptions of the externally-determined view would be sufficient.

This implies that the appropriateness of the model to be employed depends upon the particular situation of the municipality, rather than in general pronouncements about the validity or invalidity of a particular theory.

For example, Crecine, an exponent of the intra-organizational view, had success with his simulations of Detroit, Cleveland and Pittsburgh budgetary processes. In a central city, of course, one would expect tax rates to be at or above politically-acceptable limits, revenues to be pressed hard by demands for services, and debt limits approached. Then expenditures must be stabilized or cut back in order for the town to remain solvent. In such a situation, severe problems of resource allocation between programs may be expected to occur, and the importance of internal processes might indeed be strong. Further, as Whitelaw points out,[9] Crecine constructed his model and selected his data so as to control for the variability of economic, demographic and political variables.

Others, including Whitelaw, have had success with the external-determinants approach. A study by Jackson[10] attempted to include both sets of determinants, and more strongly supported the external-determinant conception as applied to Cleveland from 1945-1970.

In any case, there is good reason to suspect that in the case of a stable but growing suburban town, the above-discussed constraints might not bind so tightly, if at all, and that the tax rate would be more responsive to external demands.

In Guilford, the site of this study, the stress on environmental factors seems appropriate, since it is a study of budget determination for a small suburban community of moderately good income level. By assuming this we effect a major simplification in the structure necessary to represent the budgetary process. If it were not the case, then we could ill afford to ignore the intra-organizational processes, since they would be acting to modify priorities, which we represent with fixed coefficients.

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[9] Whitelaw, op. cit., p. 11.

[10] J.E. Jackson, "Politics and the Budgetary Process," Social Science Research: (1972).

Desiderata for a Predictive Tool

A predictive tool should have three sets of desirable features. One deals with the relationship of the community to the larger metropolitan area. The second set deals with determinants of demand for public services. The third set deals with supply aspects. Each is discussed in subsequent sections. Chart 1 summarizes the studies cited in the discussion and provides a quick recap.

Metropolitan/Local Interaction

As discussed in Chapter 2, the environment within which an organization operates is critical to understanding the behavior of the organization. It is thus first necessary to adequately account for metropolitan/local interactions, unless one is discussing a town which dominates its surrounding region. Certainly, a small suburban town does not, and is embedded in a larger system in such a way that extrapolation of past trends can be dangerous. Studies of municipal costs have typically ignored this aspect of the problem and have focused instead on the marginal contributions of growth, of whatever magnitude. The alternative has been to study a relatively autonomous town. This was the approach of Whitelaw,[11] who studied Worcester, Mass. It is clear that for purposes of prediction, one must need to adequately represent the metropolitan/local interaction where it exists.

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[11]Whitelaw, op. cit.

Chart 1

Several Studies Compared

Category / Study	Wheaton/Schussheim[1]	Mace/Wicker[2]	Muller/Dawson[3]	Whitelaw[4]
Site of Study	3 Suburbs of Boston	3 Suburban Communities in 3 States	Fringe area of Charlottesville, Va.	Worcester, Mass.
Subsystem Interface	None	None	None	Autonomous Area
Disaggregation of Determinants				
Households	No - averages	No - averages	No -	No - totals
Age of Children	Not included, but mention need for "balance"	No	Implicit by dwelling	No
Dwelling Units Types/Tenure	Single vs. multi-family; education costs same for both but other services vary	Single family units units only	Single family, townhouse, apartments	No - total units
Price or Density	Density varied for single family	Low-medium priced	Not considered	No
Time Lag of Determinants	Not considered	Not considered	Not considered	Almon lags for capital expenditure
Location	Scattered vs. compact	Not considered	New Development	Not Considered
Cost Considerations				
Public vs. Private	Public - some private noted	Accounted for both	Public only	Public
Capital vs. Recurring	Both treated	Debt service only	Yes	Yes - in detail
Existing facilities importance	Studied in detail	Ignored	New Development	In lag structure
Lumpyness of Investment	Treated	Ignored	New Development	In lag structure
Economies of Scale	Mentioned	Ignored	Implicit	In lag structure
Marginal vs. Average Cost	Mentioned	Ignored	All marginal	In lag structure
Finance Terms	Constant	Not explicitly	20 or 30 years	Not explicitly
Expenditure vs. Revenue	Not considered	Considered	Considered	Considered

Sources: [1]William L. C. Wheaton, & M. J. Schussheim, The Cost of Municipal Services in Residential Areas, Housing & Home Finance Agency (Washington, D.C.: 1955).

[2]Ruth L. Mace, & Warren J. Wicker, "'Do Single-Family Homes Pay Their Way?' A Comparative Analysis of Costs and Revenues for Public Services," Urban Land Institute, Research Monograph 15 (Washington, D.C.: 1968).

[3]Thomas Muller, and Grace Dawson, "The Fiscal Impact of Residential and Commercial Development: A Case Study," Urban Institute Paper 712-7-1, (Washington, D.C.: 1972).

[4]William E. Whitelaw, "An Econometric Analysis of a Municipal Budgetary Process Based on Time-Series Data," Unpublished Ph.D. Dissertation, M.I.T. Economics Department, (1968).

Determinants of Demand

There are three aspects of demand estimation which are of particular importance. These are: 1) disaggregation of the determinants, whether by type of household, age of children, or type of dwelling unit; 2) time lags in the determinants; 3) location of development.

Disaggregation. The determinants of demand must be estimated at a fine level of disaggregation. Different categories of household, defined on the basis of age or ethnic status, for example, can have quite different implications for projecting demands for schools or other services. The age of children is also critical, since children in the older grades are more expensive to educate. The type of dwelling unit, defined by price, density, or tenure, affects the type of households which occupy it, and has a differential effect on the demand for service.

Very little discussion appears concerning the effect of household type on demand for services. This is peculiar, since household type determines such things as fertility rates, distribution of children by age, and enrollment rates. The study by Wheaton and Schussheim does use local fertility and enrollment rates in figuring potential school costs, and the authors comment on the desirability of attracting a mix of household types, since this will tend to balance the load on the school system.[12] But in general, little systematic attention has been paid to this question.

[12] William L.C. Wheaton, and M.J. Schussheim, The Cost of Municipal Services in Residential Areas, Housing & Home Finance Agency (Washington, D.C.: 1955), pp. 87 and 97.

The same situation prevails with respect to the mix of school enrollment by age. Older children are more expensive to educate, but most studies ignore this, and instead average across the community.

Much more attention has been paid to dwelling unit type as a determinant of demand. The reasoning seems to be that: 1) dwelling unit type is controllable at the local level; and 2) certain types of households are associated with certain type dwelling units. Density has also been examined in relation to demand.

A recent study by Muller and Dawson[13] examines various types of development, both residential (single-family, "townhouse," and multi-family) and commercial, and its effect on both revenue and expenditures of a fringe area of Charlottesville, Virginia. The effects of capital expenditures were isolated, as well as the effect of various financing arrangements.

The methodology is very detailed, estimating numerous revenue and expenditure categories as a function of dwelling unit type and commercial development.

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[13] Thomas Muller and Grace Dawson, "The Fiscal Impact of Residential and * Commercial Development: A Case Study," Urban Institute Paper 712-7-1, (Washington, D.C.: 1972).

Table 1

Annual Revenue-Expenditure Summary[14]
Charlottesville, Virginia Development

Unit Type (Per Unit)	No. Units	Revenue	Operating Expenditures	Revenue Minus Expenditures	Capital Expenditures (30 year)	Net Expenditures
Single-Family	358	$643	$598	$+45	$271	$226
Townhouse	256	502	512	-10	233	243
Apartment	199	347	274	+73	137	64
Total Project per Annum (including commercial)		$503,099	$414,013	$89,086	$190,830	$101,745

The results of their analysis are summarized in Table 1, which gives the per-unit figures for each type of unit, then the total for the project, including commercial development (which was a net taxpayer). They show that, while each residential type is a net consumer of expenditures, apartment units have a relatively small impact, while single-family units, with their higher capital expenditures, are almost equal to townhouses.

As an aside, since the entire project is a "fiscal liability" to the county, the authors suggest alternatives such as requiring greater contributions from developers for capital costs, attempting to channel development into areas where the capital requirements are not so severe, or obtaining increased state aid.

The study by Wheaton and Schussheim treated the effect of density of development on the cost of services in great depth. Their study in Newton[15] shows that the marginal capital costs for multiple-family dwelling units is

[14] Source, *ibid.*, Table 34, p. 83.

[15] Wheaton and Schussheim, *op. cit.*, Table 45, p. 70.

almost one-third that of scattered growth at 10,000 sq. ft., or developments at 15,000 sq. ft., the highest cost. Accepting their methodology implies that, per acre, the ranking of the types of development by cost is reversed. Thus, multiple units are most expensive, followed by scattered growth and developments at 15,000 sq. ft. This is summarized in Table 2.

Their figures, however, include an equal amount for schools in all three types of development. In Chapter 5 below, evidence is presented which suggests that the demand placed on schools by the average renter is one-half to one-third that of the average owner. This would bring the per acre cost of multiple dwellings below that of scattered growth, as is also displayed in Table 2.

Table 2

Marginal Capital Costs in Newton[16]
(1951 dollars)

Type of Development	Per Unit	Per Acre
1. Scattered at 10,000 sq. ft.	$1,936	$7,745
2. Development at 15,000 sq. ft.	2,196	5,740
3. Multi-family at 3,000 sq. ft. (average)	670	8,930
4. Multi-family with lowered school costs	522	6,950

[16]Source: Unit Costs for 1-3, Ibid. Other figures computed by author.

Of course, this is one case study over 20 years old, but it does point up two things. First, an exclusive concentration on per unit cost can be misleading, for the integrated cost to the community is also important. Secondly, the differential impact of demand factors such as varying numbers of school children per unit must be accounted for.

Time Lags. In contrast to the very detailed and painstaking studies mentioned above, a study of San Jose by the RAND Corporation[17] took a much more aggregate, but broader, view and attempted to assess whether "private and public well-being in Santa Clara County depends only on a high, stable level of economic activity. . .[or]. . .that such well-being depends upon a rapid rate of economic growth[18] and in the process revealed the importance of lagged relationships to municipal finance questions.

They did this by testing various forms of a simultaneous equation model designed to explain changes in migration, local employment, unemployment, retail sales, property values, and income. Since they do not disucss their method of estimation, it is impossible to know if they have corrected for simultaneous equation bias, so their results must be taken on faith.

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[17]RAND Urban Policy Analysis Group, "Alternative Growth Strategies for San Jose: Initial Report of the RAND Urban Policy Analysis Project," Working Note WN-7657-NSF (Santa Monica, California: 1971), Ch. II, The Paradox of Growth.

[18]*Ibid.*, p. 10.

Because of the (significant) lags within the system, the county adapts gradually to changes in the exogenous variables. They summarize the implications of the model as follows:

> So long as rapid growth continues, the lags do not hurt the county, because the new population with its need for jobs and services which has been attracted to the county by last year's economic growth (or that of the year before) will have its needs taken care of by this year's and next year's economic growth. But if the economic growth slows down drastically, the lags mean that the population and the need for jobs and the need for public services keep increasing for a time, but the new base for supporting them does not materialize.[19]

Under a series of simulations to 1980 unemployment, their measure of private economic welfare, rose under all assumptions about lowered or declining growth rate. Depending on how it was estimated, their primary measure of public economic welfare, the market value of property, generally stayed even or declined, implying a tax increase. Only with the most favorable set of assumptions did it increase, and then only 3% in ten years.

While they did not estimate public finance equations directly, the crude macro model of the region carries a very important lesson -- even if growth as such is beneficial, dependence on growth can prove disastrous in a changing world.

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[19] *Ibid.*

A simple example can be constructed to show what the effect on the tax rate will be under this sort of a situation. It is very easy to show that if the tax base is proportional to current population but that the change in the cost of services is proportional to both current population change and the change occurring a certain number of years previous, then the tax rate will rise after population growth followed by population stability.

Assume that the current tax base (T_t) is proportional to the current population (P_t), but that the change in the cost of services (ΔS_t)[20] is proportional to current population change (ΔP_t) and the change in population k periods ago (ΔP_{t-k}). This might be true in the type of development where new houses immediately produce tax revenue, but children do not enter the schools for several years -- k would represent this lag. The present tax rate (r_t) is simply the ratio of the present cost of services to the tax base. This is:

(1) $T_t = \alpha P_t \qquad (\alpha > 0)$

(2) $\Delta S_t = \beta_1 \Delta P_t + \beta_2 \Delta P_{t-k} \qquad (\beta_i > 0)$

(3) $r_t = \dfrac{S_t}{T_t}$

If we concern ourselves only with the case where population has been rising, then levels off, justifying negative change in service costs (which may include capital investment) is not an issue and the algebra is quite simple.

[20] Here Δ is the first difference with a one year differencing interval, i.e., $\Delta S_t = S_t - S_{t-1}$ and $\Delta P_{t-k} = P_{t-k} - P_{t-k-1}$.

Thus, if $P_t > P_{t-k}$, but $P_t = P_t = P_{t-1}$ $(k > 1)$, then

$$(4)\quad \Delta r_t = \frac{S_t}{T_t} - \frac{S_{t-1}}{T_{t-1}} = \frac{\Delta S_t}{T_t}$$

$$= \frac{\beta_1 \Delta P_t + \beta_2 \Delta P_{t-k}}{\alpha P_t} = \frac{\beta_2}{\alpha} \frac{\Delta P_{t-k}}{P_t}$$

Since $\Delta P_{t-k} > 0$, the change in the tax rate is positive.

This simple example shows that the tax rate, even if it were stable while population was rising, would rise after population growth ceased, and continue to do so until the lagged relationship worked itself out. While it is not claimed that fiscal problems in San Jose or elsewhere are this simple, the example is presented as a way of isolating and studying a single determinant of fiscal change.

It is easy to generalize this model. This allows us to examine the behavior of the tax rate under a variety of regiems of growth and to make a general statement about the effect of lagged changes. We begin by noting that the formula for the difference of a ratio is analogous to that for the derivative of a ratio. This is expressed as follows:

$$(5)\quad \Delta r_t = \Delta \left(\frac{S_t}{T_t}\right) = \frac{S_t}{T_t} - \frac{S_{t-1}}{T_{t-1}}$$

$$= \frac{S_t T_{t-1} - S_{t-1} T_t}{T_t T_{t-1}}$$

$$= \frac{[S_t T_{t-1} - T_{t-1} S_{t-1}] - [S_{t-1} T_t - T_{t-1} S_{t-1}]}{T_t T_{t-1}}$$

$$= \frac{T_{t-1} \Delta S_t - S_{t-1} \Delta T_t}{T_t T_{t-1}}$$

Since

$$(6)\quad S_t = \beta_1 P_t + \beta_2 P_{t-k},$$

$$(7)\quad \Delta r_t = \frac{\alpha P_{t-1}[\beta_1 \Delta P_t + \beta_2 \Delta P_{t-k}] - \alpha \Delta P_t[\beta_1 P_{t-1} + \beta_2 P_{t-k-1}]}{\alpha^2 P_t \quad P_{t-1}}$$

$$= \frac{\beta_1 \Delta P_t + \beta_2 \Delta P_{t-k} - \Delta P_t [\beta_1 + (\beta_2 P_{t-k-1})/P_{t-1}]}{\alpha P_t}$$

$$= \frac{\beta_2 \Delta P_{t-k} - \beta_2 P_{t-k-1} \Delta P_t / P_{t-1}}{\alpha P_t}$$

$$= \frac{\beta_2 [\Delta P_{t-k} - P_{t-k-1}(\Delta P_t / P_{t-1})]}{\alpha P_t}$$

Two things are worth noting. First, the "demands" of the present increment of population, (as expressed in β_1) do not affect the rate of change of the tax rate. Second, and more important, the change in the tax rate (Δr_t) is greater, less than, or equal to zero as the proportional change from time (t-k-1) is greater, less than, or equal to the proportional change from time (t-1). This is so, since in (7) everything on the right but the expression in square brackets is positive. The sign of this expression is determined by:

$$8)\quad \Delta P_{t-k} - P_{t-k-1} (\Delta P_t / P_{t-1}) \gtreqless 0$$

$$9)\quad \frac{\Delta P_{t-k}}{P_{t-k-1}} \gtreqless \frac{\Delta P_t}{P_{t-1}}$$

since only division by a positive number and addition are involved in manipulating the inequality.

The possible movement of the tax rate under various combinations of change is summarized in Table 3.

Table 3

Response of Tax Rate to Various Growth Options

Population at Time t-k	Population at Time t: Falling	Steady	Growing
Falling	Unknown	Falling	Falling
Steady	Rising	Steady	Falling
Growing	Rising	Rising	Unknown

It shows that if the present population is steady or growing while the lagged population is steady or falling, the tax rate will remain steady or fall. If the reverse is true, the tax rate will remain steady or rise. If both populations were falling or growing, then the behavior of the tax rate depends on their relative change.

Of course, this simple model is not an accurate representation of town finance, but does illustrate some "non-intuitive effects" which lagged relationships can produce. The model could be extended toward greater realism,[21] but even in its present form warns against control policies formulated in reaction to current changes in the tax rate.

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[21] If we want to include a certain amount of fixed capital in the service required by the population at t-k, this would imply that β_2 were larger for $\Delta P_{t-k} > 0$ than for $\Delta P_{t-k} < 0$. (The same would hold true for β_1 vis-à-vis ΔP_t.) This would simply mean that a negative ΔP_{t-k} would dampen the effect on Δr_t, however.

Location of Development. The location of development can also have a bearing on the cost of providing services. This is not of overriding significance in a small town, but as the area becomes larger, it could assume greater importance. The study by Wheaton & Schussheim[22] of Natick, indicates the importance of pre-existing facilities, and by implication location of development, in contributing to the marginal cost of development. Scattered growth at 10,000 sq. ft. in built-up areas was cheapest on a per-unit basis, followed by concentrated growth at 10,000 sq. ft., and concentrated growth at 20,000 sq. ft.. Much of the increased cost of the third area was due to the necessity of providing a new school, in conformity with a town policy of community schools. However, the incremental cost to the community of the latter area developed at the 10,000 sq. ft. density was even higher.[23]

This example appeared to show how location could dominate density as a component of cost, since increased density raised even the unit cost to the town in the third area. But, as Kain points out,[24] this lower cost at the lower density comes about as a result of private provision of septic systems for the lower density area. If these costs are figured in, the total cost at 20,000 sq. ft. is still highest. It is thus not enough to examine the demand-related aspects of cost -- the supply-related aspects, such as the distinction between publicly and privately-provided services, must be considered.

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[22] Wheaton & Schussheim, op. cit., p. 13

[23] Ibid., p. 22

[24] John F. Kain, "Urban Form and the Costs of Urban Services," Harvard Program on Regional & Urban Economics, Discussion Paper #6 (Revised), (May, 1967), p. 82.

Supply Considerations

Studies of the costs of supplying urban services stretch back well over 30 years. The Wheaton-Schussheim[25] study is still one of the best, and Kain[26] has produced a lengthy discussion of many more, as well as the issues involved. We will not retread this ground except to point out the most rudimentary considerations.

There are still many problems in studying urban service supply. For one thing, there is no uniform definition of urban services.[27] Electricity, for instance, is rarely considered an urban service. Additionally, the services are provided by both public and private means, and involve a combination of capital and recurring costs. Some costs may be provided privately and others publicly. Various communities have different mixes of services and economic arrangements. We have pointed out in the last section the importance public-private distinctions can have. It is certainly important to identify precisely what is being discussed.

Just as important, however, is the inclusion of all relevant categories of cost. For example, a study by McCallum[28] omits schools and sewers and focuses on categories which make up only a fraction of municipal budgets.

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[25] Kain, "Urban Form....," op. cit.

[26] Wheaton & Schussheim, op. cit.

[27] Kain, "Urban Form....," op. cit., p. 18 ff.

[28] David L. McCallum, "A Case Study of the Cost of Government Activities in Single-Family Residential Areas of Different Density," unpublished ms., Dept. of City & Regional Planning, U. of North Carolina (Chapel Hill: 1956), cited in Kain, "Urban Form....," op. cit., pp. 90-93

Another critical aspect hinges on the process of plant expansion and investment. Wheaton & Schussheim[29] point out the importance of existing facilities, particularly underutilized capacity, and the desirability of guiding growth so as to utilize it. They also treated the lumpiness of investment and the question of economies of scale. They also point up the related question of marginal vs. average costs and its significance for town development, particularly as related to underutilized capacity.

A study which points up the importance of ignoring these questions is that by Mace and Wicker[30] which examined hypothetical, but similar, low-medium priced single-family developments on 1/2 acre lots in California, New Jersey, and North Carolina. The conclusions were:[31]

1) The developer pays virtually all initial public improvement costs;
2) Non-educational public revenues cover or greatly exceed the corresponding annual service costs;
3) Annual school costs are covered, except in New Jersey (which relies heavily on the property tax), where the deficit is slight.

The implications are that local improvement policies and state-local fiscal structure are the prime determinants of the cost/revenue balance.[32]

The obvious respect in which these conclusions must be qualified is that marginal capital investment costs, apart from on-site development, are ignored. Even if the costs of new or expanded schools, upgraded sewer plant, etc., are averaged across the community, the effect may be substantial. The authors, in contrast, average existing (recurring and debt service, apparently) costs in each community.

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[29] Wheaton & Schussheim, op. cit.

[30] Ruth L. Mace & Warren J. Wicker, "'Do Single-Family Homes Pay Their Way?' A Comparative Analysis of Costs and Revenues for Public Services," Urban Land Institute, Research Monograph 15 (Washington, D.C.: 1968)

[31] Ibid., pp. 19-20

[32] Ibid., p. 8

Another item, trivial but of practical importance, is the terms under which the expansion takes place. Muller & Dawson[33] examine varying terms for the bonds in their study.

Cost Revenue Balance

Finally, the balance between costs and revenues, not costs alone, is the item of interests from a fiscal standpoint. This is so for several reasons. Simply looking at unit costs says little about the impact on the community. Many low-cost units can introduce strain on finances. Also, due to the lagged nature of the response to growth, effects may not appear immediately. As long as growth of the tax base keeps pace with or exceeds the growth in demand for services, no strains appear. However, both the RAND study and the algebra we presented pointed up what a sensitive, and in a sense "non-intuitive" indicator the tax rate is. Certainly, it is the only indicator which has meaning for many homeowners, and which thus strongly influences political decisions about growth.

While the tax rate does not capture all that is worth looking at, it does represent the cost vs. revenue aspects of growth succinctly, and is a convenient criterion to use.

[33] Muller and Dawson, "The Fiscal Impact...", op. cit.

Chapter 4

Modeling Issues

Subsequent chapters present the details of the estimation method which was developed to address the questions raised in the last chapter. The method features the use of simulation of public school enrollment at a quite disaggregated level, and the use of econometric techniques to describe the budget formulation in the town. The choice between one method or another involves a consideration of the question of validation and accuracy. Additionally, since a model of the region in which the town is located is used to generate inputs for the models described here, the question of modeling in partitioned systems becomes relevant.

There are four separate issues here: the value of simulation; the value of disaggregation; the question of validation; and the appropriate strategy when working in a partitioned system. While seemingly unrelated, each issue turns out to be complementary to the others. For example, the choice of simulation "versus" econometric modeling, seemingly a subsidiary question to the value of simulation, turns out to be essentially a question of the choice of criterion function and method of choosing parameter values -- essentially validation and accuracy. Similarly, simulation greatly opens up the possibility for disaggregation, and it can be shown by other means that disaggregation is important in its own right.

Simulation as a Tool

Since the primary method used here is computer simulation, it is well to discuss issues surrounding its use. One might distinguish three approaches to the systematic investigation of a problem. One is to produce a "rigorous" mathematical derivation from "first principles." Another is to use mathematics in a more instrumental fashion to achieve closed-form or approximate solutions to a mathematical system which describes the phenomenon, without positing the same kind of logical necessity for the solution as is assumed by the first approach. The third is to construct a system which is partly mathematical and partly composed of complex conditionals and heuristics, then work out the implications on a computer.

In the precomputer era, axiomatic approaches and closed-form solutions were a very desirable, if not necessary, expedient. One could invest time and ingenuity in constructing a more or less general solution, then "plug-in" particular numerical examples to obtain solutions. For example, it is easier to derive general conditions from the maximum of a function, or its integral, then apply it to particular cases, rather than searching the whole space or performing numeric integration, if one must do it by hand. With a computer, however, there is not the same necessity, although there are practical limits even so. In addition much more complex structures can be represented and manipulated with computer simulation.

Unfortunately, for these historical reasons, an axiomatic approach is yet thought to be preferable by many. The weaknesses of such an approach should be pointed out. It should be emphasized at the outset that all approaches have their weaknesses. It should not be inferred from the following that axiomatic approaches are not valuable, but that they are not the *sine qua non* of systematic investigation, and that other approaches can have value in their own right.

Weaknesses of an Axiomatic Approach

Holton notes that two types of propositions are commonly held to be meaningful in philosophies of science.

> "Regardless of what scientific statements they believe to be 'meaningless,' all philosophies of science agree that two types of propositions are not meaningless, namely, statements concerning empirical matters of 'fact' (which ultimately boil down to meter readings), and statements concerning the calculus of logic and mathematics (which ultimately boil down to tautologies)... Let us call them respectively empirical (or phenomenic) and analytical statements..."[1]

In Holton's view, both components are necessary in any scientific approach-- what distinguishes one from another can be the emphasis given to one or the other. The quintessence of an approach relying heavily on analytic propositions is usually the development of a mathematical model, derived from a set of "first principles" or axioms. However, a commitment to an axiomatic mathematical approach suffers from several weaknesses.

In the first place, one's axioms may be in error. Presumably, this will be ferreted out by the individual theoretician, or, more probably, by the present and future colleagues who constitute his scientific sub-culture. However, erroneous assumptions are a danger of any approach.

A more important point is that any branch of mathematics is a construction of the human mind and need bear no necessary resemblance to "reality" whatsoever. This is true of even those branches which have become closely identified with certain theories, such as calculus and classical mechanics. As Holton puts it, "...there exist in principle infinitely many possible logical and mathematical systems, including mutually contradictory ones, from

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[1]Gerald Holton, Thematic Origins of Scientific Thought: Kepler to Einstein, Harvard University Press, (Cambridge: 1973), pp. 53-53.

which we choose those that suit our purposes."[2]

Thus, one's mathematics may be unsuitable to the problem--the types of representation it allows and the very rules of deduction it employs may be irrelevant. This may be the case with many continuous models of human behavior--for example, some applications of micro-economics. Preferences may well not be defined by differentiable functions. They are more likely at least non-differentiable, and probably, discontinuous as well. Assuming a continuous model of this sort to be an approximation to a more realistic model may bring one no closer to an accurate solution than does rounding a linear programming solution lead one to the solution of the corresponding integer program.

It cannot be overstressed that mathematical models are useful only insofar as the structure of the mathematical system is rich enough to accommodate the phenomenon under investigation. A simple example can illustrate that not every mathematical formulation is useful. Suppose we need five apples a day to live on and want to lay aside enough for a week. We would certainly not model this using a finite field of characteristic three.

Consider a finite field of characteristic three. Addition and multiplication are defined as follows:

Addition

	0	1	2
0	0	1	2
1	1	2	0
2	2	0	1

Multiplication

	0	1	2
0	0	0	0
1	0	1	2
2	0	2	1

[2] Ibid., p. 54.

This is a perfectly good field, since

a) Addition and multiplication are both commutative and associative:

$$x + y = y + x \qquad x \cdot y = y \cdot x$$
$$x + (y + z) = (x + y) + z \qquad x(yz) = (xy)z$$

b) There is a zero element for addition: $x + 0 = x$

c) There is a unique negative for each member in the field:

x	$-x$	$x + (-x)$
0	0	0
1	2	0
2	1	0

d) There is a unique identity element for multiplication: $x \cdot 1 = x$

e) There is an inverse for each non-zero x:

x	x^{-1}	xx^{-1}
1	1	1
2	2	1

f) Multiplication distributes over addition:

$$x(y + z) = xy + xz$$

One would not seriously propose counting even apples with a model defined on a finite field of characteristic three. This would be a "mathematical model" for the number of apples but would correspond to what was commonly perceived as reality only if there were two or fewer apples. On the other hand, a field of characteristic zero (e.g., the rationals) would allow counting apples and would allow one to discuss dividing 11 apples equally between two people. Other fields, such as those of the real or complex numbers, would permit other statements, such as the calculation of volumes (π not being rational).

This example is not intended to deny the utility of simpler algebraic structures--indeed, kinship has been modeled with fewer assumptions than needed for a finite field.[3] The point is simply that the structures can be inapplicable, and the use of a mathematical model (or any other, for that matter) is no guarantee of either objectivity or validity.

A Simulation as an Analytic Proposition

Since one's own biases and preconceptions are quite likely to be incorporated into any "model", formal or informal, mathematical or verbal, public, repeatable procedures are quite desirable. So are explanations which do not depend totally on "intuition" concerning the phenomenon, and which have a formal structure apart from their empirical content.

If one wishes to derive the implications of ideas without necessarily commiting oneself to a particular analytically-tractable mathematical structure, one's gaze then turns to the use of the computer. A computer program is also a device for deriving the implications of ideas. Computers can be used to perform "mathematical analysis" in symbolic form. For example, computers have been able for some time to perform symbolic integration at high levels of expertise.[4] Currently, the MACSYMA system at MIT's Project MAC can solve symbolic problems in the areas of calculus, matrix algebra, and optimization.[5] We are not proposing the use of a computer in this manner here, however.

The approach taken here, rather, asserts that an algorithm is an analytic proposition. It is, after all, a set of symbolic logical propositins which one manipulates to draw conclusions. The output of this process

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[3] Harrison White, The Anatomy of Kinship; Mathematical Models for Structures of Cumulated Roles, Prentice-Hall, (Englewood Cliffs, N.J., 1963)

[4] Joel Moses, Symbolic Integration, Project MAC, TR-47, (December, 1967), and Eugene Charniak, CARPS - A Program Which Solves Calculus Word Problems, Project MAC, TR-51, (July, 1968).

[5] Mathlab Group, Project MAC, MACSYMA Reference Manual, Version 6, (January, 1974).

may be yet another symbolic expression. Any structure, or combination of structures, may be employed. A great deal of complexity may be introduced -- one is not bound to a search for "parsimonious" representations in terms of simple, closed-form expressions (which may themselves be actually limit of a particular function). A disadvantage, of course, is that statements about the existence and uniqueness of a solution cannot be made without much searching. However, in complex problems, such statements are not so easily made in any case.

In this study, a set of logical propositions has been expressed on a computer, then used to derive the implications of empirical observations into statements which could be checked against other observations. These propositions have evolved over time based on the outcomes of previous experiments of the same sort. It is not claimed that this method is the only valid one which could have been employed in this situation, only that it is a method which seems to work.

If this seems like an overly pragmatic justification, it should be pointed out that Newton's calculus had very weak logical underpinnings, but was found to be useful in the representation of certain physical problems. Faith sustained its advocates, while its critics, such as Bishop Berkeley, could mount cogent criticism. It was not until the work of Cauchy that satisfactory statements about limits and continuity were made. If work in the area had been suspended until rigorous proofs, over 100 years in the making, could be supplied, a great deal of valuable work would have been lost. The value of the present work aside, avoiding a method simply because its value has not been proven beyond doubt seems counterproductive.

The above is certainly not meant to imply that mathematical characterizations are to be avoided, or that deductive-inductive approaches based on them are not useful, but that at this stage in our knowledge about social phenomena, exclusive reliance on them may be too confining. For example, the theoretical models stemming from Alonzo's work have yielded important insight into the structure of metropolitan areas. The study of canonical examples can indeed be fruitful. However, the comprehensive explanation of urban processes via this route would seem to lie in the distant future, and radical reformulation would be required at that.

In contrast, the approaches taken in this work follow no particular party line: "simulation," with heavy use of judgementally-chosen time-varying parameters, is coupled back-to-back with a simple system of econometrically-estimated linear, constant-coefficient equations. The approach which seemed appropriate for the problem was used.

Themata

This brings us to the third demension of Holton's philosophy of science, that of themes:

> "This third dimension is the dimension of fundamental presuppositions, notions, terms, methodological judgments and decisions--in short, of themata or themes--which are themselves neither directly evolved from, nor resolvable into, objective observation on the one hand, or logical, mathematical, and other formal ratiocination on the other hand."[6]

Themata, in his view, appear in dialectic relationships, with one of each pair dominant at any one time. In his view:

> "Since Parmenides and Heraclitus, the members of the thematic dyad of constancy and change have vied for loyalty, and so have, ever since Pythagoras and Thales, the efficacy of mathemetics versus the efficacy of materialistic or mechanistic models. The (usually unacknowledged) presuppositions pervading the work of scientists have long included also the thematic couples of experience and symbolic formalism, complexity and simplicity, reductionism and holism, discontinuity and the continuum, hierarchical structure and unity, the use of mechanisms versus teleological or anthropomorphic modes of approach."[7]

Much of the modeling and simulation done in the social sciences today seems to be dominated by the themes of constancy, the efficacy of mathematics, symbolic formalism, simplicity, reductionism, the continuum, hierarchical structure, and the use of mechanisms. On the other hand, this work, and that upon which it is based, tend to support the other of each pair. We will discuss each pair in turn. It should be stressed that the following discussion

[6] Holton, op. cit., p. 57.

[7] Ibid., p. 29.

is not based on Holton's, nor would he probably agree.

Constancy vs. Change. At some level, all models embody fixed coefficients, of course. However, this need not be confined to proportional relations among levels, as in a linear statistical model. Much of the statistical work today deals with linear, constant-coefficient equations, since linearity in the coefficients eases the fitting process considerably. Much of the mathematical work deals with comparative statics. For example, Mills argues that "... a well formulated equilibrium model is a precondition for a useful dynamic model, and characteristics of the equilibrium positions tell us something about the dynamic adjustment."[8] The appeal of "systems-dynamics" and control-theory approaches stems from their explicit attention to change. The time path of adjustment, *per se*, may well be the most crucial information from a policy perspective.

Mathematical vs. Materialistic Models. Some of the weaknesses of a total reliance on mathematical models have been given above. Certainly, a computer model can be a step away from mathematical formalism, although not a "materialistic model" in the literal sense. For example, one might simulate an aircraft in a wind tunnel and gain a rich explanation of behavior, yet be able to try more cases with a computerized model, maintaining some of the richness of the physical model, while providing more flexibility than a totally "abstract aircraft" modeled purely mathematically. Particularly in social systems, where experimentation in the wind tunnel sense is often impossible or immoral, a simulation can have great appeal.

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[8] Mills, *op. cit.*, pp. 62-63.

Symbolic Formalism vs. Experience. In part, this overlaps the pair above. However, it can also refer to the distinction between imputing a system of theoretical relations a priori vs. a naturalistic approach of close observation of the phenomenon under investigation. Computer simulation, while not tramping out in the bush, tends to force the issue of verification in a way that a purely abstract model does not.

Simplicity vs. Complexity. Mathematical abstractions tend to be simple. Complexity introduces intractability and/or tedium. It is not denied that much can be learned from the study of simple cases. However, this should not rule out the complexity which a computer simulation can allow. Even though one's ultimate purpose may be to reduce an explanation to the simplest terms possible consistent with the phenomena, it does not follow that one must necessarily begin with a simple explanation, and work one's way through a series of others. An alternative strategy is to begin with complexity and attempt to see where simplification can be achieved.

Reductionism vs. Holism. This relates to the above pair, but on a different plane. There is a danger of studying only partial equilibrim effects, for example, which can be a result of the study of parts of a system in isolation. The fundamental question here is whether the behavior of individuals in groups is reducable to, or explainable only with reference to the behavior of the individuals involved. In our discussion of micro-economic theories of urban residential distribution, we mentioned that the model of perfect competition employed may have the weakness of ignoring those interactions which do seem to exist--among groups of people, for example. Simulation tends to force the issue of separability early, and, in any case, provides a more flexible medium for implementing a more holistic conception.

Continuity vs. Discontinuity. This has been commented on above. In subsequent chapters it appears that important discontinuities exist in our problem.

Hierarchical Structure vs. Unity. There is a partitioning of interaction, but not necessarily hierarchy, which is essentially anthropomorphic projection. Clearly, a hierarchy exists where it is constructed by humans--in most organization, for example. However, this does not imply that all behavior can be modeled with a cybernetic-type conception of information flowing down and energy flowing up. Rather, there may be simply a partitioning of interaction with signals of various sorts flowing back and forth across the boundaries. One objective of the budget analysis reported below was to examine what was important in terms of flows across the town boundaries.

Mechanistic vs. Teleological or Anthropomorphic Modes of Approach. Humans being teleological, it may well be dangerous to seek too diligently for mechanistic descriptions. A simulation provides the ability to subvert a mechanism to see what happens. One is not duty-bound to use historically-fitted coefficients, for example, or any other structure which fits the past.

Summary

This section has attempted to suggest that, while more deductive styles of enquiry have enjoyed prominence for a considerable period, that the computer has greatly changed the way in which it is possible to solve problems. A simulation provides a public, repeatable procedure, and one with considerably greater versatility than traditional methods. It can be used however, in ways which do not accord with what has commonly been perceived as "scientific", which may account for some of the resistance to its use.

Importance of Disaggregation

Disaggregation is of importance to modeling for two principal reasons. The first has to do with the identification of parameters, the second with the representation of the effects of changing population composition on the observed aggregate behavior.

With regard to the second question, if the "mix" of a population is changing, and if the various segments of the population respond differently, then disaggreation is necessary if this changing response is to be captured. For example, if the composition of a school system shifts toward later grades, the cost of education per pupil will rise, since children in later grades are more expensive to educate than those in earlier grades. If the changes occur smoothly through time, the ill effects of ignoring disaggregation will be mitigated, but not eliminated.

This refers to the use of a model -- disaggregation can improve the output obtained, particularly its sensitivity to changes in inputs. The other side of this question is that of accurately estimating the parameters of individuals from data. It turns out that this cannot be reliably done with observations on whole groups. This question falls under the rubric of "aggregation bias", and a brief examination of what is known about it is instructive.

Aggregation Bias

In the previous section, it was suggested that discontinuity is important in the study of human behavior. Different categories of people act differently, and these differences cannot necessarily be modeled continuously. One can attempt to represent such discontinuities by fitting a smooth surface through them. This is parsimonious in terms of parameters, and favored by many analysts. One technique stemming from the general linear model is the analysis of variance model, which attempts to reconstruct individual mean values with linear and multiplicative relations of various qualitative "effects". While the analysis of variance can yield valuable information about such relations, it still seeks to impose a structure which may or may not be useful. An alternative is to work directly with the discrete, unstructured categories, such as age groupings rather than age.

A conventional approach is to ignore differences by aggregating classes of households, firms, etc. The question is usually forced by an inability to work with all the detail considered appropriate, and a consideration of the costs in accuracy introduced by such aggregation.

This question, that of aggregation bias, has received considerable attention from economists, who often need to attempt the estimation of valid relationships from data which are means over whole populations. The results are not reassuring. Rather than "smoothing" individual error, aggregation may propogate it, both in other coefficients in the same equation, and in other equations in a system. This can be shown analytically, to a certain extent, in the well-understood world of linear statistical models. That the effects are worse in non-linear models can be inferred, since superposition of solutions is not valid.

Consider a simple problem -- the estimation of the amount of sugar consummed as a linear function of various exogenous variables. One might estimate this for the entire population or for each subgroup. Is the first method valid?

Theil, for example, has shown that each parameter in the macro (aggregated) equation is biased by all the other parameters in the micro (disaggregated) relations.[9] Thus, we may attempt to estimate the relations determining consumption of sugar as a function of the household's income, price of sugar, price of coffee, etc. Sugar consumption could be expected to vary across groups defined along racial, occupational educational, or age lines. There may thus be a separate set of coefficients for each group. However, if we aggregate along one or more important dimensions before fitting the equation, the estimated macro coefficients (e.g., for income) will be biased not only by the variation between groups for that coefficient (the income coefficient for each group) but also in general by the variation of all the other micro coefficients (price of sugar, coffee, etc.) for all groups. Obviously, the most likely case in which this result will not hold is that in

[9]Henri Theil, Principles of Econometrics, Wiley (New York: 1971), pp. 558-559.

which the micro-parameters for all groups are equal. Further, if the coefficients between groups for coffee prices are the same, the coffee coefficients will not affect the income coefficients. But, in general, one cannot safely assume the problem away.

One can also aggregate over commodities, sets of commodities or individuals, time, or sets of simultaneous equations. The problems are generally similar. Fisher has shown[10] that specification error, of which aggregation bias is one type, affects instrumental variable estimation of systems as well, and has different effect depending on the estimator, although they are in the same direction. Further, it sould be observed that specification error has a less pervasive effect in limited information methods (e.g., two-stage least squares), where the error is confined to the block of equations in which it occurs, than in full-information methods (e.g., three-stage least squares), where it can extend throughout the system.

It has been proposed that aggregation can be an aid in prediction. For example, Grunfeld & Griliches[11] argued that, whereas if errors were uncorrelated across individuals, aggregation would not help, but prediction in the aggregate would be better than the aggregate of individual predictions if positive errors were balanced by negative errors. Zellner,[12] however, has pointed out that this is a misconception arising from a misstatement of the problem. The proper estimator in this case is his estimator for "seemingly

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[10] Franklin M. Fisher, "The Relative Sensitivity to Specification Error of Different K-Class Estimators," Journal of the American Statistical Association, (June, 1966), pp. 345-356; and ______________, "Approximate Specification and the Choice of a K-Class Estimator," JASA: (December, 1967, pp. 1265-1276.

[11] Y. Grunfeld & Z Griliches, "Is Aggregation Necessarily Bad?." Review of Economics & Statistics: (1960), pp. 1-13.

[12] Arnold Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions & Tests for Aggregation Bias," Journal of the American Statistical Association: 57 (1962), pp. 348-368.

unrelated regressions," or Joint Generalized Least Squares. This estimator is useful when there exist "contemporaneous covariances", e.g., equations representing several firms operating in the same economy, the effects of which might produce correlated disturbances if the effects are not directly represented in the equations. If this estimator is used, one cannot do worse with a disaggregated model, and may do better.

The main point is that one should strive to get as close to a one-to-one relationship between actors and their behavior as possible. Of course, there is a practical limit to the amount of disaggregation possible, or desirable. Among the limits are such practical considerations as time, money, and sufficiently rich concepts. A serious statistical point is that disaggregation reduces sample size, and this tends to increase the variance within a cell. One may prefer to work with classes of individuals if the variance within a class is significantly less than that between classes, if such classes can be found and if they have substantive meaning, i.e., are not simply the artifacts of statistical manipulation.

The Role of Simulation

Taken literally, the statement above implies modeling the behavior of each individual, or class of individuals, as a unit, stepping them through life cycles of birth, marriage, death, etc., in short bursts of time in a probablistic manner. This is commonly referred to as a Monte Carlo method because random numbers generated from various probability distributions are used to select which individuals in a homogeneous class will take an action at a particular time. This can be caused by the need to choose which of two people, or both, or neither, will take an action if its probability is, say, .7. However, it is the disaggregation, not the probablistic character, which is of the greater importance. At any point in time, a "census" can be taken to determine the state of the system. This approach is, of course, always available in principal. One of the first large-scale simulation efforts proceeded in precisely the above manner.[13]

However, utilizing this amount of detail involves problems. As Harris points out:[14]

1) the number of households required for representativeness is large, and hence the computer storage requirements are also large;
2) the short time intervals dictate large computer run times;
3) the detailed knowledge of probabilities is often not known;
4) the detailed set of initial conditions is not known.

Numbers 3 & 4 are not insurmountable problems, given the existence of Census Public Use Sample files on individuals and families, and the existence of methods for estimating probabilities based on various transformations (e.g., logit, probit) with regression analysis[15] on individuals, or by the analysis of contingency tables.[16] But numbers 1 & 2 are severe constraints.

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[13] Guy Orcutt, A.M. Rivlin & M. Greenberger, A Micronanalysis of Socio-Economic Systems: A Simulation Study, Harper (New York: 1961).

[14] Britton Harris, "Report on Household Projection Model," unpublished ms., Institute for Environmental Studies, University of Penna., (May, 1969), p.4

[15] See Theil, op. cit., pp. 628-635, for a discussion of the use of and pitfalls involved in the various regression-based methods.

[16] See David L. Birch, R. Atkinson, S. Sandstrom, L. Stack, The New Haven Laboratory: A Test-bed for Planning, Lexington Books, D.C. Heath (Lexington, Mass.: 1974), pp. 45-50, for an approach to the estimation of joint frequencies from marginals; and T. C. Lee, G. G. Judge & A. Zellner, Estimating the Parameters of the Markov Probability Model from Aggregate Time Series Data, North Holland (Amsterdam: 1970), for a discussion of other method including restricted and unrestricted ordinary and generalized least squares, maximum likelihood estimation, and minimization of absolute error with linear programming. Of course, more general mathematical programming formulations could also be used. Here the emphasis is upon estimating the parameters of a Markov chain, but the techniques are more generally applicable, and not merely to estimating probabilities.

To avoid working with such detail, the approach taken in this study, as well as in the work on which it is based, seeks to aggregate households into a large but manageable number of categories. These classes of households are then described by equations. This approach preserves those discontinuities which do exist, or those where it is not possible to specify the relationship more fully, without the need to find a continuous approximation for the relationship.

There seems to exist a very close link between the use of computer simulation and disaggregation. This is no accident-- the computer allows the storage and retrieval of large tables of possible values or outcomes. Hence it is not necessary to describe the function in terms of a few parameters and relations -- all relevant values may be retained.

Validation and Accuracy

The question of validation--how good is the model--is an important one which can be handled in a variety of ways, at least for the historical period. For the future, validity depends upon one's belief that the structure is rich enough to capture both the past and changes which may occur in the future. For this reason, it is useful, and perhaps more profitable, to provide a structure which validly represents the past (and many may) but which can be changed. The question of validity can then be answered by the user by simulation under various sets of assumptions in a way suitable to himself.

For statistically-fitted models, where assumptions are made about the distribution of coefficients, procedures typically based on sums of squared residuals and the F-ratio are available. One can also make assertions about prediction intervals, etc., to measure the uncertainty of the forecast.

In the absence of statistical fitting, one can look at a measure such as the percent error, which we have been using. This criterion is simply the ratio of the difference between actual and predicted values to the actual value.

Alternative measures are also available. Several based on Theil's inequality ratio [17] have been proposed,[18] but we have not used them , primarily because how they behave in various situations is not well understood, so their use is no less arbitrary than the percent error.

In fact, any choice of measure of error involves problems. We will

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[17] Henri Theil, Economic Forecasts and Policy, North Holland (Amsterdam: 1961), pp. 154-161.

[18] de la Vallee Poussin, and Edwin Kuh, "Forecast Evaluation in the Absence of Statistical Fitting," unpublished ms., MIT Sloan School of Management (March 1971).

comment on the practical probelms below. But, for fitting parameters, all measures have drawbacks. The sum-of-squared-residuals measure is analytically tractable, and has been studied for over 150 years. Its properties are well known in many situations. However, it tends to weight outliers very heavily and is sensitive to them. Absolute deviations are harder to work with and their properties less well known. The percent error has the same weakness as that of the average error --that large negative errors can balance large positive errors. However, it is easily understood.

Choice of a technique also involves choice of a measure of error, and this should be borne in mind. In fact, the purposes of seemingly different techniques may be essentially the same -- the primary difference may lie in the choice of error measure and method of choosing parameters. If one attempts to estimate "structural equations", [19] a regression approach is then simply defined by the use of a certain criterion of goodness (namely, the use of a minimized sum of squared error), in choosing parameter values. It is not a separate "approach" as such.

The choice of measure cannot be made independently of the use of the estimates or model. For example, a 10% error may mean only a few students in a small school district, yet mean ten classrooms in a larger district. Clearly the impact of the mistake would be different in each situtation. The requirements for accuracy would be different depending upon the time span for the estimate or the cost of making an error. For example, delaying the expansion of a high school might cause crowding or higher costs, and might preclude site acquisition at the later date. The considerations need not be incorporated explicitly, although they might. However, they should be at least borne in mind in interpreting the results.

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[19] See Franklin M. Fisher, The Identification Problem in Economics, McGraw-Hill (New York: 1966), ch. 1.

Modeling in Partitioned Systems

As we indicated in Chapter 2, the forces affecting a small town in a metropolitan region are diverse and not of its own making or even control. Thus, the interactions across its boundaries are crucial and must be accounted for. To accomplish this in our study, we relied on a previously-developed model of the SMSA, described below.

However, the output of this model was not directly usable for planning at the local level--its output consisting of counts of households by gross age categories, and the like. In contrast, local planning efforts require data at the level of detail noted in Chapter 3. School planning for example, requires yearly data on school children by age groupings and enrollments by grade, to name the most basic. For fiscal projections, the output should include budget line items, taxable property estimates, the mill rate, debt requirements, and similar items.

Thus the critical problem is how to transform the estimates which come from the larger system model into locally-useful terms. By modeling the processes which actually occur we can accomplish this task quite easily.

Just as in the actual system there are flows back and forth across the boundaries of subsystems, so it is useful in the model to partition the interactions into regional and local sets, and to concentrate on the latter. We have assumed that this was a reasonable approach in part because the evidence in favor of strong feedback effects from the local municipality to the region is weak. In addition, our purposes are 5-10 year forecasts, and it is not clear that feedback effects, if they exist, would respond in a significant manner in that length of time.

We have been able, with the aid of the SMSA model, to treat the local municipality as a separate, closed, entity and relying on the larger model to perform the accounting for the flows across the boundaries.

There are really two questions here. One is how significant are the flows axross the boundaries for the local municipality. That is, in the aggregate, are the town's problems not of its own making, or are they generated internally. The second is somewhat more specific. If there are significant exchanges, which are the most important.

The New Haven Model

Since the model developed in this study relies on a comprehensive model of the New Haven SMSA, in this section we provide a cursory overview of this model in order to acquaint the reader with its main features.

The major variables which are estimated at the census tract level in the SMSA model are jobs by industry, persons by type, households by type of head and tenure, housing units by tenure and price, and land use by type.

Employment is estimated by ten industry categories[20] for the region and their location within the region. The births, deaths, aging, and educational mobility of persons by thirty-six (four age, three ethnicity, and three education) categories[21] are accounted for at the tract level. The land use by seven categories[22] resulting from the movement of jobs and households is also

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[20] Industry categories: Non-durable manufacturing, construction, transportation, communication and utilities, wholesale trade, retail trade, finance-insurance - real estate, services, government.

[21] Population categories: Age: 0-19, 20-39, 40-64, 65 +; ethnicity; White native, foreign born, minority; education: less than, equal to, greater than high school.

[22] Land use categories: residential, light manufacturing, heavy manufacturing, trade and service, vacant - easy to build, vacant - hard to build, unavailable.

accounted for by tract. These variables are somewhat peripheral to our analysis, although they do enter in.

Of greater importance are dwelling units by six tenure and price categories,[23] and households by twenty-seven types of the head of household and the six dwelling unit type.[24]

Households are formed and dissolve, move into and out of the region, and move within the region in response to changes in available jobs and dwelling units. Households move into or out of a tract on the basis of four variables: social class, recent growth, percent minority, and recent change in percent minority. Each of these may "excite" or "suppress" movement into an area. Different household types respond to varying permutations of these four variables. There are thus: $\sum_{i=0}^{4} (\sum_{j=o}^{4-i} j!) = 86$ possibilities for each of twenty-seven household types. Various automated ways of deciding on which were the most important moving determinants for each household type were developed. The results cannot be summarized in a few sentences, and the reader is referred to the original work for such description.

This moving experience and the pressures it applies stimulate construction and vacancies by tract, as well as a certain amount of "filtering" of the stock in value terms. Changes in a year feedback to modify the characteristics of the tract next year.

Several aspects of this model stand out. One is its comprehensive nature. The important components of a metropolitan area are all represented, if crudely in some cases. Another is the extreme amount of disaggregation and complexity involved, and a structure which could only be estimated by

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	Tenure	
Price 1970	Owned	Rented
Low	$20,000	$80/mo.
Medium	$20 - 32,999	$80 - 130/mo.
High	$33,000 +	$131 +

24 Household heads: same as population except no 0-19 heads.

simulation, not by conventional statistical techniques.

Third is the relatively weak linkages between the location of people and their jobs. In part this is due to the size of the region and the assumed shape of the distance-to-work function. In addition empirical studies of households' location behavior have not found this to be an important factor, although it is assumed important in many models.

The final point is the explicit incorporation of the factors we cited in Chapter 2 as important, unsolved problems in location theory: externalities, particularly of minorities; clustering by social class; the effect of a fixed, slowly-varying stock of housing; and the time dependencies of all the above factors.

Chapter 5

Estimation of School Enrollment

A substantial fraction of town budgets is spent for education. In 1970 education expenditures averaged over the 37 largest SMSA's made up not quite one third (31%) of total expenditures in central cities, and a little over one half (53%) in towns in the suburban ring. The range was moderate, 24-50% for central cities, and 43-77% for suburban towns.[1] For suburban towns, school expenditures are obviously the most important item of the budget.

The importance of schools, in terms of the percent of the budget, is growing somewhat as well, (up 2% for both central cities and suburban towns) but not for all towns.[2]

Costs are escalating rapidly. Expenditures per pupil in constant dollars rose by 2/3 in the 1959-'69 decade, from $428 to $713 per pupil (1967 dollars).[3] In addition the school age population (ages 5-17) rose by 22%, and enrollment rates were rising. As a result of these and other influences, total elementary and secondary expenditures for the nation more than doubled from $20.4 bil. to $41.3 bil. (1967 dollars).[4]

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[1] Joel S. Berke and John J. Callahan "Inequities in School Finance: Implications of the School Finance Cases and Proposed Federal Revenue Sharing Programs" (a paper presented at the 1971 Annual Convention of the American Academy for the Advancement of Science, dated December 1971). Table VII, pp 54-55, of Committee Print , Select Committee on Equal Education Opportunity, U.S. Senate (Washington DC - 1972).

[2] Ibid.

[3] Figures in current dollars from table on page 14 of Francis Keppel, "The Cost-Revenue Squeeze," in Financing Public Schools, Federal Reserve Bank of Boston (Boston - 1972). Consumer price index with 1967= 1.0 used.

[4] Ibid.

Although the school-aged population is expected to drop by 1979, projections by the Tax Foundation foresee expenditures per pupil rising by more than one quarter, and total expenditures rising by more than one fifth.

It should be pointed out that average rates for the nation as a whole obscure the locational component of these changes. While the numbers of school-aged children have begun to level off or decline nationally, the numbers in suburban areas have continued to increase. Table 1 illustrates these trends for 1960-1970.

This is partly due to an existing concentration of fertile-aged couples in the suburbs, but also has resulted from a movement of households with children to the suburbs. Recent estimates of migration from 1970-1973 bear this out. As can be seen from Table 2, the majority of children who move, move elsewhere than to the central city of an SMSA. The movement outside an SMSA is probably in large measure to suburban areas not included in the SMSA definitions.

To put these figures in perspective, Table 3 displays the difference between the movement of the population aged 3-14 and the movement of the total population. Table 3 shows that the age group now 3-14 years of age has a mobility rate higher than the overall population, and that, in addition, a greater proportion of this group moves to a suburban ring or outside an SMSA.

Since growth of the school-aged population may well continue to be a problem in suburban areas, even if the growth of the school-aged population stabilizes nationally, and since enrollments determine a large fraction of school costs, we have concentrated considerable attention on the estimation of numbers of school children.

Current Methods of Estimation

The current methods of estimating school enrollments illustrate the dangers of ignoring the flows of households within the metropolitan area within which a municipality is located. The methods currently used by the town under study seem to be the most commonly employed in the field. We will discuss each briefly in turn.

Cohort (or percentage) survival is the most prevalent method, and

Table 1

Percentage Change, 1960-1970
By Age and Residence

Age Group	Total All Areas	Metropolitan Areas Total	Metropolitan Areas Central City	Metropolitan Areas Fringe	Non-Metropolitan
< 5	-12%	-10%	-21%	1%	-15%
5-13	+13	+19	+ 3	+33	+ 3
14-15	+46	+53	+35	+68	+31
16-19	+41	+55	+29	+81	+21
All Ages 0-99+	+13	+17	+ 2	+32	+ 7

Source: U.S. Census Bureau, "Social and Economic Characteristics of the Population in Metropolitan and Non-Metropolitan Areas: 1970 & 1960", Current Population Reports, Special Studies, Series P23 #37 (June, 1971), Table 1, p. 15 as basis.

Table 2

Percentage of Population 3-14 By Mobility Status
1970-1973

Residence in 1973

		Central City	Ring of SMSA	Outside SMSA	Total Movers	Total Non-Movers
	Central City	7.3%	3.9%	1.1%	12.3%	17.1%
	Ring of SMSA	1.9	8.0	1.6	11.5	25.1
Residence in 1970	Outside SMSA	.7	1.2	9.4	11.3	18.8
	Total	9.9	13.1	12.1	35.0	61.0

Abroad 1.1%
No Report 3.0%

Source: U.S. Census, "Mobility of the Population of the United States, March 1970 to March 1973," Current Population Report, p.20, #256, November 1973, Table 1, pg 3.

Notes: Movers include those between as well as within SMSA's.

Table 3

Difference, Percentage of Population 3-14 Minus
Percentage of Total Population, By
Mobility Status, 1970-1973

Residence in 1973

		Central City	Ring of SMSA	Outside SMSA	Total Movers	Total Non-Movers
Residence in 1970	Central City	+.2%	+.3%	0%	+ .5%	-1.8%
	Ring of SMSA	+.1	+.7	+ .3	+1.1	+ .5
	Outside SMSA	-.1	+.1	+1.6	+1.6	-1.4
	Total	+.2	+1.1	+1.9	+3.2	-2.8

Source: Computations based on ibid.

is required by law in some states. It is based on a population projection technique applicable to a relatively closed system, such as a national population. This technique "ages" cohorts of kindergarteners or first-graders though the system with fixed percentages of "survival," which are based on observed patterns. For example, 98% of first-graders may go on to the second grade, 99% of second-graders go on to the third grade, and so on. This percentage is computed as the ratio of observed enrollments in grade k at time t to observed enrollment in grade k + 1 at time t+1. This is done for each pair of adjacent grades. Trends over time may be noted and incorporated into estimating the coefficients.[5]

Obviously in practice, the "survival rate" can frequently be greater than one! This is so because this method attempts to incorporate into a single fixed coefficient a variety of different, sometimes opposing, forces. The most important of these is migration, which can cause major changes in school population in a relatively short time, both in absolute numbers and in population mix by age or type of student. Secular changes in enrollment rates in schools generally, and public schools in particular, are not anticipated. Changing fertility patterns are not anticipated. Death rates and school retardation policies are assumed constant. These weaknesses are acknowledged by practicioners[6] but methods of dealing with them are often impressionistic.

That the method is most sensitive to migration rates is indicated by a study performed of the accuracy of the method.[7] In forecasting school enrollments seven years in advance predictions were off more than 10% in magnitude in over 60% of the 242 towns. Of the successful predictions, half

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[5] See New England School Development Council, Enrollment Forecasting Handbook: Introducing Confidence Limit Computations for a Chohort - Survival Technique, New England School Development Council (Newton Mass. - 1972), chapters 6-8, for a description of the technique.

[6] Ibid., ch. 4

[7] George J. Greenwalt, assisted by Donald P. Mitchell, Forecasting School Enrollment, New England School Development Council (Cambridge, Mass. 1966)

A similar lack of predictability in growing versus stable areas, using a totally different technique, was found by Ruth Fabricant and Janice Weinman, "Forecasting First Grade Public Enrollments by Neighborhood," Demography: 9 (1972).

were in towns experiencing net migration of less than 10% in magnitude. Further, there was a tendency for overestimation of enrollments to occur in towns experiencing outmigration, and underestimation to occur in towns experiencing immigration. The relationship held even more strongly when the change in school enrollments was considered, rather than migration.

The above results reinforce our earlier observation that the method is most applicable to a stable system.

The cohort survival method has been modified by the consideration of the numbers of building permits in a community in past years. While this is a step in the right direction, it provides no way of determining the characteristics of migrants which might influence school enrollments. In addition, it only considers net, not gross change. Finally, no method of predicting future building permits which incorporates metropolitan-wide dynamics seems to be provided.

Exponential smoothing has been utilized.[8] This is a short-term adaptive forecasting tool of great simplicity which is particularly valuable for tracking short-term changes in a large number of rapidly-moving items.

The basic concept is very simple. The new prediction (P_t) is a convex combination of the past prediction (P_{t-1}) and the past actual value (A_{t-1}). Thus:

$$P_t = (1-\alpha) \; P_{t-1} + \alpha \; A_{t-1} \qquad 0 \leq \alpha \leq 1$$

Trend and seasonality predictions can also be generated in a similar manner, and incorporated into the prediction. The larger the smoothing constant (α), the greater the weight given to errors in the immediate past.

Its advantages are its simplicity, ease of computation, flexibility, ease of implementation relative to other techniques, and its accuracy relative

[8]For a good general discussion see: Robert Goodell Brown, Smoothing, Forecasting, and Prediction of Discrete Time Series, Prentice-Hall (Englewood Cliffs, New Jersey: 1963); see also: Christopher Sprague, Exponential Smoothing: An Extension, M.I.T. Sloan School of Management Working Paper 189-66. (1966).

to its simplicity. On the other hand its short-term nature makes it unsuitable for even medium-range forecasting, and the choice of smoothing constant can be very subjective.

Exponential smoothing is a quite special case of the auto-regressive integrated moving-average technique (ARIMA) developed by Box & Jenkins in the last decade.[9] This is a statistical technique which utilizes only past values of the series, or differences of the series, and past errors of estimation in making a forecast. Here the parameters are statistically fitted.

While this method is an improvement over exponential smoothing — being more general and less subjective -- and has apparently not been used in school forecasting, it suffers from the same short-term weakness as does exponential smoothing. This is that as a forecast is extended close to the limit of the lags involved in the structure, or beyond, the forecasts follow the deterministic trend inherent in the parameters and initial conditions.

Overview of the Estimation Method

Before proceeding to a technical description of the method and the data analysis which forms a basis for it, it is well to consider what it is which should be represented. That is, what are the influences thought to be most significant in determining school enrollment.

In the previous section we mentioned the migration of households into and out of a town as the most important determinant of enrollment changes. In a growing town the number of housing starts provides a rough index of such changes. However, this measure provides no information on gross movement -- only net changes are represented. More importantly, the composition of the changes is not known. The age, education, or ethnicity of the household head has an important bearing on the number and age distribution of children in

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[9] G.E.P. Box and G.M. Jenkins. Time Series Analysis, Forecasting, and Control. Holden - Day (San Fransisco - 1970).

the family, as will be shown in a later section. Any method which ignores disaggregation of this sort must rely on a stable population of households to hope for any sort of accuracy. But in a growing community, this sort of stability may be achieved only by chance.

Even in a community which is not growing, in and out-migration may act to change the composition of the population. For example, in a town with a good school system, couples may move in with young children, stay until they are educated, then move out, to be replaced by other couples with the same intentions. The age mix of the school population may well change, although the total number of families remains the same.

As we will see below, length of residence has a strong impact on the age distribution of children -- the longer the residence the older the mix of children. This means that it is important to know the balance between in and out-migration, not simply the net difference.

Not only are the characteristics of the household important in determining numbers of children, but the tenure (owned or rented) and price index important differences in both number and age distribution of children.

Fortunately, the New Haven model provides yearly estimates of the composition of the population, as well as estimates of in and out-migration for twenty-seven different categories of household head (three categories each of age, education, and ethnicity), and six categories of dwelling unit (three price classes by own/rent). It does this at the census tract level, and provides an accounting of the flows across the boundaries of the town in a way consistent with region-wide dynamics.

How this basic input is combined with other data, and the structure which is employed to produce estimates of public school enrollments, is described in greater detail in subsequent sections. The basic flow of the algorithm is depicted in Figure 1, and the remainder of this section should be read with reference to that figure.

There are two major estimates which are made. The first is the yearly estimation of numbers of children by age. The second, utilizing the numbers of children as input, determines yearly public school enrollments.

Determination of the numbers of children by age begins with the numbers of households classified by characteristics of the head and of the dwelling unit. An estimate of households by length of residence in Guilford is then made. Estimates of the number and age distribution of children for each household head/dwelling unit/migration status category for 1970 are combined with numbers of households to produce an initial estimate of numbers of children. Since these estimates are valid only for 1970, methods for changing the age mix and family size over time are applied to produce yearly estimates of the numbers of children. It is also necessary to adjust the overall level of the estimates to correspond with differences in the local versus the national experience.

This having been done, children are translated into public enrollments by grade. There are three steps to this process. First, the number of children enrolling in school at all is estimated. The enrollment rates for this purpose are derived from the same 1970 data sample for each type of household head. Since enrollment rates have been rising over time, this change must be incorporated into the procedure as well. Second, not all children enrolled in school attend public school. These rates vary by the type of household head and have been rising over time, but in different ways from enrollment rates generally. These rates are estimated in a manner formally similar to the enrollment rates. Third, enrollments by age of child must be mapped into enrollments by grade, to be of use for school planning. The matrices for doing this are estimated from the same data by type of household head.

This structure was arrived at by an iterative approach of trying a simpler structure, noting patterns in the errors, and correcting the specification of the model in meaningful ways. In our discussion of the technical aspects, we show the results of some of these intermediate steps. In Table 4 is shown the final set of estimates, and the errors made, from 1960 to 1973.

Figure 1

School Enrollment Estimation - Yearly

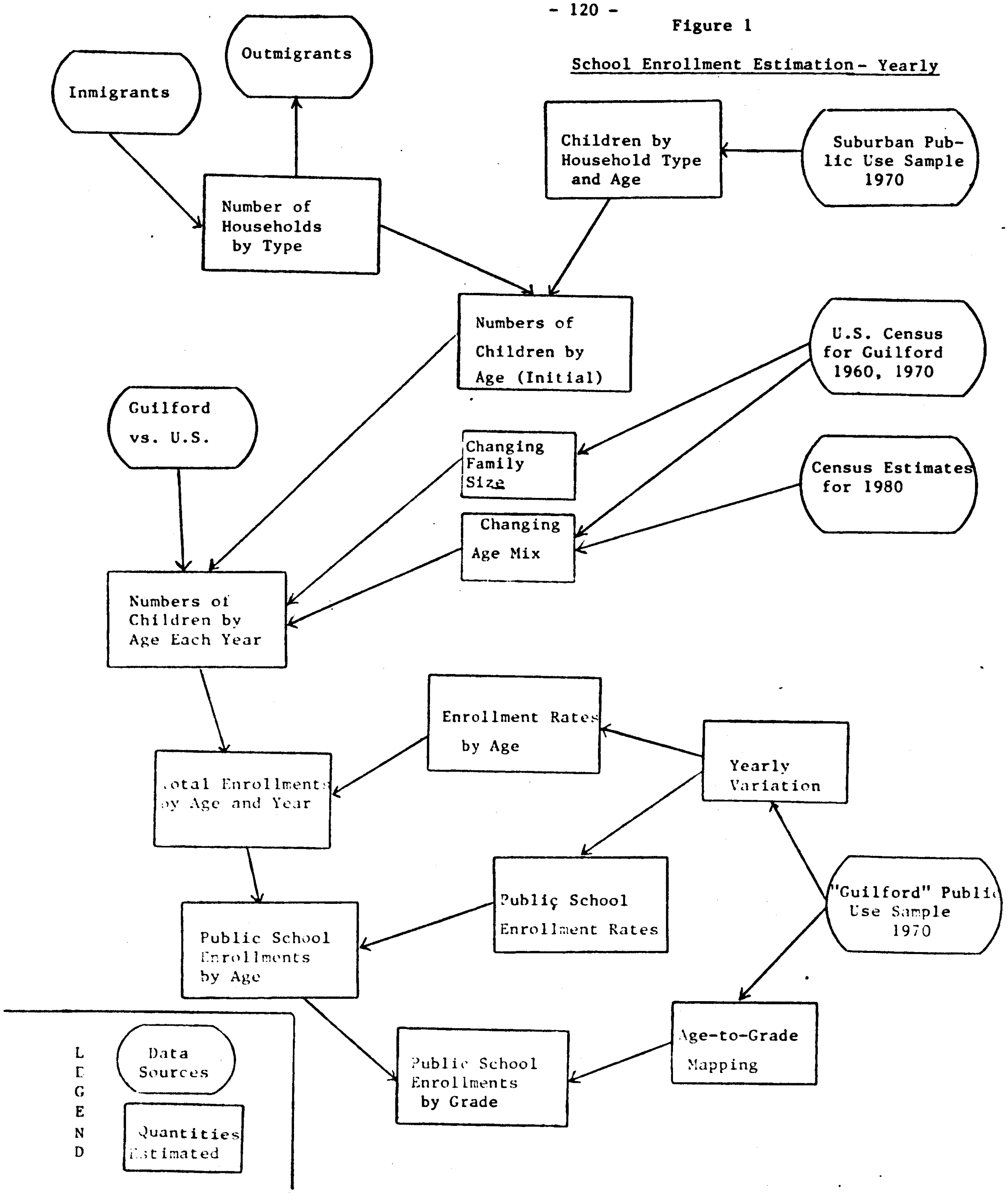

Table 4

Estimates of Enrollments, 1960-1982

REPORTS FOR YEAR 1960

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	172.	796.	425.	379.	1771.
ACTUAL	181.	790.	450.	370.	1791.
DIFFERENCE	-9.	6.	-25.	9.	-20.
PERCENT ERROR	-5.23	0.72	-5.61	2.33	-1.14

REPORTS FOR YEAR 1961

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	181.	822.	437.	395.	1835.
ACTUAL	183.	862.	441.	395.	1881.
DIFFERENCE	-2.	-40.	-4.	0.	-46.
PERCENT ERROR	-1.16	-4.63	-1.00	0.06	-2.46

REPORTS FOR YEAR 1962

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	188.	853.	451.	416.	1907.
ACTUAL	196.	876.	439.	449.	1960.
DIFFERENCE	-8.	-23.	12.	-33.	-53.
PERCENT ERROR	-4.01	-2.66	2.66	-7.37	-2.68

REPORTS FOR YEAR 1963

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	200.	912.	476.	445.	2032.
ACTUAL	210.	931.	470.	451.	2062.
DIFFERENCE	-10.	-19.	6.	-6.	-30.
PERCENT ERROR	-4.81	-1.99	1.17	-1.43	-1.44

REPORTS FOR YEAR 1964

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	209.	971.	504.	475.	2159.
ACTUAL	224.	1047.	440.	503.	2214.
DIFFERENCE	-15.	-76.	64.	-28.	-55.
PERCENT ERROR	-6.89	-7.22	14.49	-5.55	-2.49

REPORTS FOR YEAR 1965

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	213.	1024.	538.	515.	2291.
ACTUAL	236.	1070.	504.	567.	2377.
DIFFERENCE	-23.	-46.	34.	-52.	-86.
PERCENT ERROR	-9.64	-4.32	6.76	-9.10	-3.64

REPORTS FOR YEAR 1966

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	214.	1075.	575.	566.	2429.
ACTUAL	217.	1133.	543.	579.	2472.
DIFFERENCE	-3.	-58.	32.	-13.	-43.
PERCENT ERROR	-1.38	-5.15	5.87	-2.29	-1.73

REPORTS FOR YEAR 1967

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	219.	1148.	620.	625.	2613.
ACTUAL	279.	1195.	592.	646.	2712.
DIFFERENCE	-60.	-47.	28.	-21.	-99.
PERCENT ERROR	-21.42	-3.92	4.72	-3.19	-3.66

REPORTS FOR YEAR 1968

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	222.	1225.	669.	693.	2809.
ACTUAL	266.	1303.	661.	661.	2891.
DIFFERENCE	-44.	-78.	8.	32.	-82.
PERCENT ERROR	-16.57	-5.98	1.25	4.83	-2.83

REPORTS FOR YEAR 1969

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	226.	1326.	729.	775.	3057.
ACTUAL	305.	1438.	724.	718.	3185.
DIFFERENCE	-79.	-112.	5.	57.	-128.
PERCENT ERROR	-25.76	-7.79	0.73	7.93	-4.03

REPORTS FOR YEAR 1970

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	255.	1505.	791.	828.	3380.
ACTUAL	271.	1507.	803.	793.	3374.
DIFFERENCE	-16.	-2.	-12.	35.	6.
PERCENT ERROR	-5.95	-0.11	-1.50	4.47	0.17

REPORTS FOR YEAR 1971

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	251.	1472.	796.	876.	3395.
ACTUAL	262.	1492.	810.	865.	3429.
DIFFERENCE	-11.	-20.	-14.	11.	-34.
PERCENT ERROR	-4.24	-1.31	-1.78	1.24	-1.00

REPORTS FOR YEAR 1972

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	251.	1465.	812.	933.	3461.
ACTUAL	238.	1526.	848.	960.	3572.
DIFFERENCE	13.	-61.	-36.	-27.	-111.
PERCENT ERROR	5.58	-4.01	-4.28	-2.83	-3.12

REPORTS FOR YEAR 1973

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	256.	1478.	835.	991.	3560.
ACTUAL	244.	1531.	943.	1026.	3744.
DIFFERENCE	12.	-53.	-108.	-35.	-184.
PERCENT ERROR	4.93	-3.48	-11.48	-3.38	-4.92

REPORTS FOR YEAR 1974

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	261.	1519.	875.	1072.	3726.

REPORTS FOR YEAR 1975

PUBLIC SCHOOL ENROLLMENT

	KINDER- GARTEN	ELEMEN- TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	280.	1583.	918.	1150.	3931.

REPORTS FOR YEAR 1976

PUBLIC SCHOOL ENROLLMENT

	KINDER- GARTEN	ELEMEN- TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	298.	1653.	961.	1222.	4134.

REPORTS FOR YEAR 1977

PUBLIC SCHOOL ENROLLMENT

	KINDER- GARTEN	ELEMEN- TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	325.	1762.	1025.	1317.	4429.

REPORTS FOR YEAR 1978

PUBLIC SCHOOL ENROLLMENT

	KINDER- GARTEN	ELEMEN- TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	351.	1872.	1093.	1423.	4739.

REPORTS FOR YEAR 1979

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	380.	1985.	1164.	1535.	5064.

REPORTS FOR YEAR 1980

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	408.	2110.	1244.	1657.	5420.

REPORTS FOR YEAR 1981

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	431.	2217.	1316.	1771.	5736.

REPORTS FOR YEAR 1982

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	471.	2438.	1443.	1926.	6279.

The 1970 Public Use Sample and Variable Definitions

Sample

The data used in estimating age distributions by family type, enrollment rates, and the age-to-grade mapping matrix came from the 1970 Public Use Sample from the U.S. Census[10]. The particular file utilized was the Neighborhood Characteristics, from the 15% questionnaires. The only directly geographical information this file contains is the geographic division of the country[11], and size of urbanized area[12].

There are three classes of records in this file: neighborhood, household, person.

The "Neighborhood Characteristics Record" contains characteristics about the area in which the household lives. The areas are census-tract size (about 4,000 people) but are not geographically identical to census tracts. The 55 data items are in the form of proportions of persons, households, or dwelling units in various categories and refer to a subsequent group of households and persons[13]. It thus gives a certain amount of "ecological" information about households which can be used in the selection of households or in

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[10] U.S. Bureau of the Census Public Use Samples of Basic Records From the 1970 Census: Description and Technical Documentation. (Washington, D.C.: 1972)

[11] New England, Middle Atlantic, E.N. Central, W.N. Central, S. Atlantic, E.S. Central, W.S. Central, Mountain, Pacific.

[12] Categories: Outside Urbanized Areas; Inside Urbanized Areas: In central city or remainder of areas, (50,000-499,999; 500,000-999,999, and 1,000,000+ size). A programming error by the Bureau obscured the breakdown of the "Outside Urbanized Areas" category, see U.S.Bureau of the Census, "Small-Area Data Notes," Vol.8 No. 12, p.s.

[13] See Census, Public Use Samples...., op cit.,

ecological analysis.

A series of household/person sets follow each neighborhood record. The household record provides information about the housing unit and summary information about the resident household, if the unit is occupied. As many person records as there are members of the family follow each household record; sixty-two items of information are recorded for each person.

Variable Definitions

It was necessary to: a) choose a geographic basis for sampling; b) make the household head and dwelling unit types conform as closely as possible to the definitions used in the New Haven model, which we used to estimate numbers of households; c) define age, enrollment, and grade categories for children.

Neighborhood type. There were three possibilities. One, we could have used all the records, but many areas are quite different from the town we were studying in racial composition, proportion of single-family units, proportion of primary individuals, and associated fertility and enrollment characteristics. A second alternative is to use only households in the remainder of urbanized areas of greater than 50,000 population -- we termed this the "suburban" sample.

However, "suburbs" under this definition may include large areas not unlike the central city yet not politically incorporated into it -- it is a political rather than a socio-economic definition. The third alternative, then, is to attempt to filter out those neighborhoods unlike the one under study using neighborhood characteristics. We did this using the following criteria:

Primary individuals/households	<.2
Negro population/total population	<.1
Single-family units /total year-round units	>.75

This was termed the "Guilford-like" sample. It had the disadvantage of filtering out blacks, for whom we wanted to estimate coefficients, but could be used for whites.

Household Type. Households were classified by tenure, rent/value, and characteristics of head. Tenure and rent/value are as follows:

Chart 1

Rent/Value Breakpoints - 1970

Price Category	Owned Value	Monthly Rent
Low	< $20,000	< $80
Medium	$20,000-34,999	$80-130
High-1	$35,000-49,999	$131-180
High-2	$50,000 +	$181 +

Tenure. Own is "owned or being bought," rent is rented for cash rent. Occupants of cooperatives, condominiums, and those with no cash rent were excluded[14].

Value. The value categories correspond to the New Haven model's in 1970 except for the boundary between medium and high for the owned category. In the New Haven model it is $34,999 category. This difference was forced by the coding of value on the tape.

High value was futher broken out in our tabulations, in an attempt to better capture the reality of the current housing market. Unfortunately, this resulted in too small a sample size in the highest category for meaningful tabulations, and High-1 was combined with High-2.

Household head. Classification into 27 types according to three categories of age[15], ethnicity[16], and education[17], which correspond to those used in the New Haven model, was performed.

Relationship. Relationship was designated on each person record. Head's record was used to score the household type (see above). The record for the Wife was discarded (female heads with husbands present were unfortunately designated "wife," and the husband "head"). All other persons were tabulated if they met the age, type of school attended, and grade criteria.

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[14] The New Haven model included "no cash rent" in the lowest price class. The exclusion of condominiums is not serious in the pre-1970 era.

[15] 20-39, 40-64, 65+.

[16] White, Foreign Born, Puerto Rican stock and other races (not foreign born).

[17] Completed <, = ,> 12-years of school.

Years at Address. This variable was developed from the year the head moved into the unit, and was coded as follows: 1965-1970 (0-5 years); 1960-1964 (6-10 years); 1959 or earlier (11+ years). This is not the same as the year the head moved into the community, but for a suburban community probably serves as a rough proxy.

Age of Children. The categories 0-4, 5, 6-10, 11-14, 15-18, 19 years were used. Those over 19-years were discarded. These categories were determined as most relevant for school planning by the Superintendent of the Guilford school system.

Type of School Attended. The categories were: enrolled in public school, enrolled in parochial or private school, not enrolled.

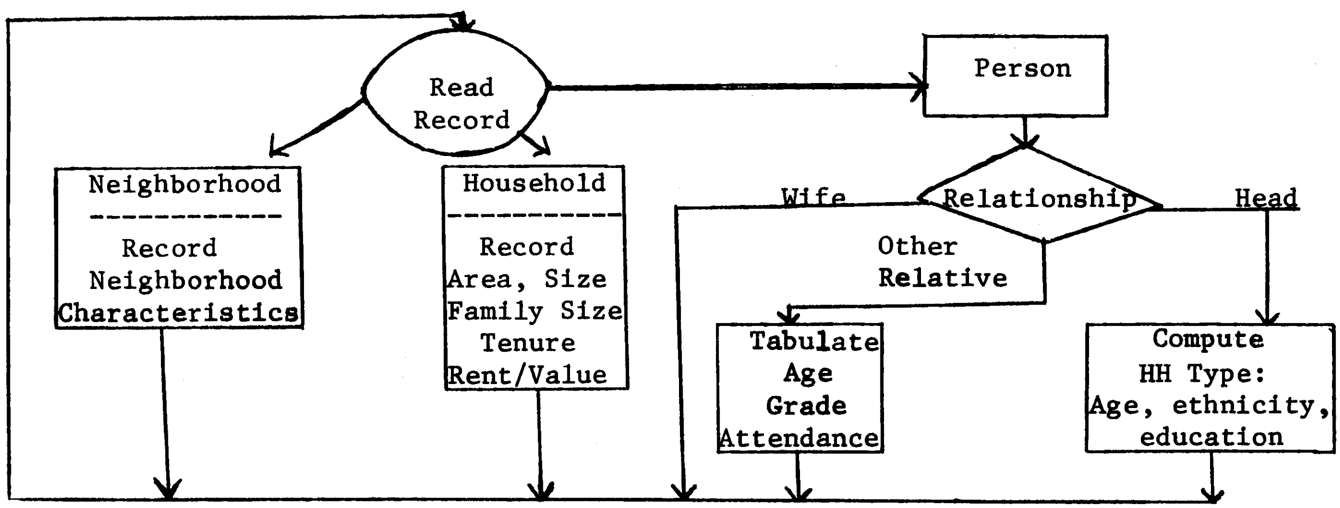
Grade. Grades were: Kindergarten, 1-5 (elementary), 6-8 (middle), 9-12 (high). These correspond to the divisions in the Guilford school system.

Retrieval

The logic is straightforward, and displayed below:

Figure 2

Retrieval Flowchart



Age Rates by Household and Dwelling Unit Type

The basis for the estimating method was information on the family size and age distribution of children in a family. A matrix was tabulated from the 1970 Public Use Sample by age, education and ethnic status of the head, by ténure category and price of the dwelling unit, and by years at this address as discussed in the last section. Only records from the East North Central, New England and Middle Atlantic states were utilized. This provided us with about 32,300 households, of which over 23,500 could be scored for all categories of household head and dwelling unit type.

As mentioned in the previous section, we constructed three samples: 1) all households; 2) households outside central cities in areas greater than 50,000 population ("suburban" sample); 3) a selection of areas based on neighborhood characteristics similar to the town under study ("Guilford" sample).

The number of children per household was, as expected, highest for the Guilford sample. This is displayed in Table 5, which displays the distribution of children by age category by tenure by price for each sample for all household heads. For owners, for all price categories, there is a slight rise in total numbers of children per household from the full to the suburban to the Guilford sample. For renters, the suburban sample tended to be lowest in total children for all price categories, and the Guilford sample was higher than the full sample.[18]

The suburban sample was utilized. This was done primarily as a trade-off between the need to represent the behavior of suburban households (i.e., exclude small and large households with different rent/value and fertility characteristics in the central city) yet maintain at least a moderate number of households in each category, particularly for foreign and minorities, which the Guilford-like sample did not provide. By using the suburban sample, an almost two-fold increase in the number of renter households was achieved.

[18]These relationships also tended to hold when the table was broken down by household head type, although these results are not presented.

Table 5

Age Mix and Numbers of Children by Tenure/Price of Unit by Samples

Total Sample

Owned Units

Value	0-4	5	Ages of Children 6-10	11-14	15-18	19	Total Children	Total Households
Low	18%	5%	28%	25%	21%	3%	1.27	7743
Medium	19	5	29	24	21	3	1.54	4380
High	16	4	29	27	22	2	1.76	1490
Total	18	5	29	25	21	3	1.41	13613

Rented Units

Value	0-4	5	6-10	11-14	15-18	19	Total Children	Total Households
Low	30	6	25	20	17	3	.68	2200
Medium	34	6	26	18	14	2	.99	4368
High	33	6	25	19	15	3	.96	3354
Total	33	6	26	18	15	3	.91	9922

Suburban Sample

Owned Units

Value	0-4	5	Ages of Children 6-10	11-14	15-18	19	Total Children	Total Households
Low	19%	6%	29%	24%	20%	4%	1.32	2271
Medium	18	4	30	24	21	3	1.59	2443
High	16	4	29	27	22	2	1.81	1013
Total	18	5	29	25	21	3	1.52	5727

Rented Units

Value	0-4	5	6-10	11-14	15-18	19	Total Children	Total Households
Low	31	6	27	19	16	3	.58	305
Medium	38	5	23	17	15	2	.81	842
High	33	6	24	18	15	3	.87	1266
Total	35	5	24	18	15	3	.81	2413

Guilford Sample

Owned Units

Value	0-4	5	Ages of Children 6-10	11-14	15-18	19	Total Children	Total Households
Low	19%	5%	29%	24%	20%	3%	1.37	3691
Medium	19	5	30	24	20	3	1.64	2518
High	16	4	30	27	21	2	1.81	969
Total	18	5	29	25	20	3	1.52	7178

Rented Units

Value	0-4	5	6-10	11-14	15-18	19	Total Children	Total Households
Low	29	6	27	20	16	3	1.32	368
Medium	41	6	23	18	11	1	1.19	553
High	32	5	27	19	16	3	1.17	557
Total	35	6	26	19	14	2	1.21	1478

Family size varied by ethnicity, age, and education of the head as well as tenure and value of the dwelling unit, and year moved into dwelling. We discuss each in turn, but the discussion refers only to the suburban sample from this point on.

Effect of Household Head Characteristics

The effect of ethnicity, controlled by tenure and age of head, is displayed in Table 6. For owners and older renters,[19] minorities had the most children, followed by white natives, and the foreign born. However, for the younger renters, whites had the fewest children.

Of course, younger households had larger numbers of children than older. The ratios of numbers of children in young to older families is given in Table 7. For owners, this ranged from 1/3 more for minorities, to 1 1/3 more for whites with less than high school. For renters, older and younger minority families had the same numbers of children, while younger whites with less than high school had 2/3 more children. For both owners and renters, the disparities between older and younger households narrowed with increasing education.

The role of education on the family size of whites was generally to lower family size. This is also illustrated in Table 6. As one would expect, higher educational attainment was associated with fewer children for renters and young owners. For older owners, the relationship was reversed, however. The explanation for this latter finding seems to be that education delays childbearing (or marriage) in the younger years, and pushes it into later years. Thus, the apparent relationship is the effect of the shift.

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[19]Although Table 6 includes age 65+, we ignore this category, and refer to 20-39 as "younger", and 40-64 as "older" or "middle aged".

Table 6

Numbers of Children by Head Type and Tenure

(Suburban Sample)

Tenure	Age	Ethnicity	Education All	<HS	=HS	>HS
Own	20-39	White	2.39	2.61	2.41	2.27
		Foreign Born	2.31			
		Minority	2.44			
	40-64	White	1.45	1.13	1.50	1.79
		Foreign Born	1.25			
		Minority	1.71			
	65+	All	.10			
Total Owners			1.52			
Rent	20-39	White	.98	1.55	1.08	.63
		Foreign Born	1.12			
		Minority	1.71			
	40-64	White	.82	.92	.71	.73
		Foreign Born	.62			
		Minority	1.77			
	65+	All	.02			
Total Renters			.81			

Table 7

Ratio of Numbers of Children in Young & Middle-Aged Families

(From Table 6)

Tenure	Ethnicity	Education All	<HS	=HS	>HS
Own	White	1.6	2.3	1.6	1.3
	Foreign Born	1.8			
	Minority	1.4			
Rent	White	1.2	1.7	1.5	.9
	Foreign Born	1.8			
	Minority	1.0			

The difference which education makes on the distribution of children by age in a family is illustrated in Table 8. This table reveals that, as education level rises for the 20-39 year age group, the distribution of children shifts to the younger ages. Thus, the earlier education is completed, the earlier families are formed. In the 40-64 age group, those with the least education have the smallest numbers of children remaining at school age, those with a high school education have a relative concentration in the older age groups, and those with the most education have a greater proportion of their children at home and in younger grades.

Associations with Housing Unit Characteristics

For characteristics of household heads, it is possible to speak of the "effect of" ethnicity, education, and age. Each of these various labels is an index of whom a person associates with, what values the person is likely to have at least been exposed, or point in the life cycle the person is (for age), and serve as proxies for these values and experiences. When it comes to type of dwelling unit a household occupies, we are not observing a "cause" of household behavior, but the effect of both values of the household for certain lifestyles and needs for space.[20] We have thus taken an approach which, by knowing that presence of children prompts choice of unit,

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[20] See Alden Speare, Jr., "Homeownership, Life Cycle, and Residential Mobility," Demography: 7 (1970), pp. 451-458, and Albert Chevan, "Family Growth, Household Density and Moving," Demography: 8 (1971), for a documentation of the importance of family size for moving and choice of unit.

infers numbers of children from an observation of choice of unit. This is, in a sense, the inverse of a strictly behavioral approach. The association is nonetheless real, however. In addition, choice of unit is an easily-observable property of actual households, and its use is further justified for this reason as well.

That the choice of unit should not be ignored is emphasised in that the most striking aspect of the difference in numbers of children is the variation by tenure -- owners have about two times the number of children overall as do renters (see Table 6). Table 9 displays the ratios of average number of children in owned versus rental units by the characteristics of the head. The ratio is higher for younger households than for older, and higher for white and foreign born than for minority households. For whites, the higher is the education of the head, the greater is the disparity between owner and renter categories.

Table 8

Percentage Distribution of Children
By Age and Education of Head for White Owners

Head Age/Education*		Ages of Children 0-4	5	6-10	11-14	15-18	19	Number of Children
20-39	<HS	23%	7%	38%	23%	8%	1%	2.61
	=HS	29	7	39	19	6	0	2.41
	>HS	37	8	37	14	3	1	2.27
40-64	<HS	6	3	21	30	33	7	1.13
	=HS	7	2	21	30	35	5	1.50
	>HS	7	3	24	32	31	3	1.79

* HS = High School

Table 9

Own/Rent Children Ratio by Household Type
(From Table 5)

Age	Ethnicity	Education All	<HS	=HS	>HS
20-39	White	2.4	1.7	2.2	3.6
	Foreign Born	2.1			
	Minority	1.4			
40-64	White	1.8	1.2	2.1	2.5
	Foreign Born	2.0			
	Minority	1.0			
65+	All	5.0			
All	All	1.9			

Table 10

Ratio of Children in Own/Rent Units
By Age of Child and Value of Unit
(From Table 5, Suburban Sample)

Value of Unit	Age of Children 0-4	5	6-10	11-14	15-18	19	Children Total
Low	1.4	2.3	2.5	2.9	2.9	2.5	2.3
Medium	.9	1.8	2.5	2.8	2.8	2.0	2.0
High	1.0	1.4	2.5	3.1	3.0	1.3	2.1
Total	1.0	1.8	2.2	2.7	2.7	2.0	1.9

In addition, the disparity between owner and renter households is greatest in the children's school-aged years. Table 10 details these ratios by age of child and value of unit.[21] The ratio is well above 2.5 in most cases for ages 6-18, and much higher than for the other ages.

Other things being equal, a higher rent or value of the unit tends to be associated with larger numbers of children. Table 11 presents these findings controlled by household type and tenure. This relationship held more strongly for older households than younger. It also held for owner and renter groups. It did not significantly change the relationship of numbers of children with educational attainment, except for young owners in high-value units. Thus higher education is associated with smaller numbers of children, except for older owners and younger owners of high-value units, for which the relationship was positive.

There was, however, a decrease in family size with increasing value of owned units occupied by minorities and the younger foreign born. One explanation for this might be that it is more necessary for these couples to limit their fertility in order to achieve a higher standard of living. In any case, these exceptions underscore that the "higher value/more children" pattern does not hold for all types of people. It is, in addition, not particularly strong for other groups.

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[21] It should be pointed out that the ratios of Table 9 are not comparable to Table 10. The former are restricted to head's age 20-64, while the latter, prepared from Table 5, include all ages. However, it is the patterns which are of primary interest, not the exact magnitudes.

Table 11

Numbers of Children by Type of Head and Value of Unit

(Suburban Sample)

Owners

Household Head			Value of Unit				Numbers of
Age	Ethnicity	*Educ.	Low	Medium	High	Total	Households
20-39	White	<HS	2.58	2.68	2.59	2.61	290
		=HS	2.39	2.38	2.78	2.41	541
		>HS	1.97	2.24	2.53	2.27	667
	**For. Born	ALL	3.23	1.83	2.56	2.31	51
	Minority	ALL	2.66	2.23	1.00	2.44	48
40-64	White	<HS	1.11	1.14	1.23	1.13	1101
		=HS	1.34	1.64	1.45	1.50	954
		>HS	1.36	1.78	1.93	1.79	955
	For. Born	ALL	1.00	1.18	1.84	1.25	236
	Minority	ALL	1.80	1.69	.50	1.71	92
65+	ALL	ALL	.12	.07	.13	.10	792
ALL	ALL	ALL	1.32	1.59	1.81	1.52	5727

* Education
**Foreign Born
HS = High School

Table 11

(Continued)

Numbers of Children by Type of Head and Value of Unit

(Suburban Sample)

Renters

Household Head			Value of Unit				Numbers of
Age	Ethnicity	*Educ.	Low	Medium	High	Total	Households
20-39	White	<HS	1.30	1.57	1.59	1.55	208
		=HS	1.15	1.19	1.01	1.08	343
		>HS	.60	.54	.65	.63	448
	**For. Born	ALL	.67	.97	1.24	1.12	100
	Minority	ALL	1.43	1.60	1.91	1.71	83
40-64	White	<HS	.75	.69	1.22	.92	325
		=HS	.65	.87	.62	.71	215
		>HS	.75	.22	.91	.73	132
	For. Born	ALL	.25	.63	.72	.62	85
	Minority	ALL	1.38	1.73	2.08	1.77	66
65+	ALL	ALL	.03	.04	.01	.02	408
ALL	ALL	ALL	.58	.81	.87	.81	2413

* Education
** Foreign Born
HS = High School

Associations with Duration of Residence

There was a marked "life-cycle" effect which appeared when the data were tabulated by years at present address. One aspect was a tendency for family size to peak in the 6-10 years of residence category. The other was for the distribution of children by age within a family to shift to older ages the longer the residence. These results, broken out by tenure and price of the unit, are presented in Table 12. The peaking is found in low and medium value owned units and medium and high value rental units. For all categories, it is evident that percent of children less than six is negatively related to length of residence, while percent of children over ten is positively related. These observations also apply when the data are controlled by household head type, although these tables are not shown.

While these results are in part an artifact of the variable definition -- duration of residence being an index of the passage of time and aging -- the effect is marked, and should not be ignored. Additionally, the result seems trivial only because it is so familier. There is no necessary relation between lack of mobility and childrearing, except as it is culturally defined and practiced.

Table 12

Age Mix and Numbers of Children
By Duration of Residence and Tenure/Price of Unit

(Suburban Sample - All Households)

Owned Units

Low Value

Years at Address	Ages of Children 0-4	5	6-10	11-14	15-18	19	Total Children	Total Households
0-5	33%	8%	29%	18%	10%	2%	1.79	610
6-10	16	7	35	23	16	3	1.96	425
11+	6	2	22	31	32	7	.86	1236
Total	19	5	28	24	20	4	1.32	2271

Medium Value

0-5	31	5	31	18	13	1	1.85	847
6-10	13	5	36	24	19	3	2.07	565
11+	5	2	21	32	34	5	1.13	1031
Total	18	4	30	24	21	3	1.59	2443

High Value

0-5	22	5	32	24	16	1	2.16	464
6-10	10	3	29	31	23	4	2.11	223
11+	6	2	20	33	36	4	1.11	326
Total	16	4	29	27	22	2	1.81	1013

Total Owned

0-5	29	6	31	20	13	2	1.91	1921
6-10	14	5	35	25	19	3	2.04	1213
11+	6	2	21	32	34	5	1.00	2593
Total	18	5	29	25	21	3	1.52	5727

Table 12

(Continued)

Age Mix and Numbers of Children By Duration of Residence and Tenure/Price of Unit

(Suburban Sample - All Households)

Rented Units

Low Value

Years at Address	Ages of Children 0-4	5	6-10	11-14	15-18	19	Total Children	Total Households
0-5	40%	5%	28%	15%	10%	2%	.69	173
6-10	17	7	31	28	14	3	.54	54
11+	3	7	17	24	41	7	.37	78
Total	31	6	27	19	16	3	.58	305

Medium Value

0-5	48	6	17	14	12	3	.80	573
6-10	21	3	39	19	17	1	.87	129
11+	13	1	34	27	23	3	.78	140
Total	38	5	23	17	15	2	.81	842

High Value

0-5	37	6	24	15	14	3	.87	1071
6-10	13	4	29	31	19	4	.90	112
11+	8	2	16	46	23	5	.73	83
Total	33	6	24	18	15	3	.87	1266

Total Rented

0-5	41	6	22	15	13	3	.83	1817
6-10	17	4	34	25	17	2	.82	295
11+	10	2	26	32	26	4	.66	301
Total	35	5	24	18	15	3	.81	2413

Summary

This section has examined a number of possible determinants of differences in numbers and ages of children. Age, ethnicity, and education of head, tenure and price of unit, and length at address were all seen to have important effects. Careful reflection would have suggested many. The importance of the above section lies in the finding that the fluctuations are large, and not always ordered in a continuous manner. Reversals of a pattern also occur. At this stage of our knowledge, it would be a heroic, if not impossible, task to specify all of the dynamics of which these patterns are a result. The point which strongly suggests itself is that the differences cannot be ignored, but probably cannot be captured with a continuous approximation. It would seem wiser at this stage to use the discrete, unstructured categories.

The specific findings related to the coefficients are as follows:

- For owners and older renters, minorities had the most children, followed by whites and the foreign born.
- For younger renters, whites had the fewest children, and minorities the most.
- Younger households had greater numbers of children than older, but this disparity narrowed with increasing education of the head.
- Increasing education generally lowers family size, except for older owners, where the relationship is reversed.
- Owners have about two times the number of children overall as renters. The ratio is higher for younger than older households, and for white than minority or foreign-born households. The disparity increases with rising education of the head.

- The owner-renter disparity is greatest for the school-aged population, those 6-18 years of age.
- A higher rent or value is associated with larger numbers of children, other things equal, except for minority and young foreign-born owners.
- Family size tends to peak at 6-10 years of residence in a dwelling unit, and the mix of children becomes older with increasing length of residence.

In general, what the results of this section emphasise is the importance of disaggregation for the modeling of the age and numbers of children in a town. This is so because of the possibility for changes to occur in the composition of the population by age, ethnicity, or education, or through changes in the type of housing built and sold, or through changes in migration status. Numbers or ages of children displayed associations with all of these variables, not always of a monotonically-varying nature, and any approach which smooths through one or more will be the less sensitive to the effect of changing community composition for that.

Estimating Children Over Time

In the previous section, we have seen how numbers of children and their distribution by age are associated with the age, ethnicity and education of the head, the price and tenure type of the dwelling unit, and the length of residence of the household in the unit. The New Haven model provided yearly estimates of numbers of households by household head and dwelling unit type for the town, taking account of demographic and housing market interactions within the region as a whole. For a description of how this was done, the reader should consult Birch, et al.[22]

It was then necessary to estimate the distribution of these households by length of residence in town. These numbers of households times the numbers of children by type provided initial estimates of children, but it was then necessary to account for the changing family size and age distribution of children in order to accurately represent yearly variations in the numbers of children.

Households by Migration Status

The New Haven model provided estimates of in and out-migration, household formation and dissolution by type of head. It also provided estimates of numbers of households by head and housing unit type. Duration of residence in town seemed to be an important factor in explaining variations in family size and age mix. Since the New Haven model did not supply this information, it was necessary to infer it. This required:

a) estimation of the initial distribution of households in 1960

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[22] David L. Birch, R. Atkinson, S. Sandstrom, L. Stack, The New Haven Laboratory: A Test-Bed for Planning, Lexington Books, D. C. Heath (Lexington, Mass.: 1974).

by head and housing unit type and duration of residence; and b) specification of an algorithm for allocating outmigrants in a year to the length of residence categories.

1960 Households by Length of Residence. The algorithm described below for estimating yearly changes in households by length of residence required as initial conditions estimates of the proportion of households which inmigrated in each of the last five years. As reported in the 1960 Census, Guilford had the distribution of households by length of residence as displayed in Table 13. The year-moved-in categories are too gross for our purposes, and yearly estimates were derived in the following manner.

It was assumed that a negative exponential distribution would describe the distribution by year moved in. The model would thus be:

$$p(t) = c\ e^{-bt}, \text{ or}$$

$$\log p(t) = c - bt,$$

where p(t) is the proportion arriving in year t. The semi-logarithmic model was fitted to estimate the parameters c and b. The data came from Table 13, with t being the average years-at-address of each category and p(t) the proportion. The results of this estimation are shown in Table 14.

This equation was used to estimate the per cent at the address for each year up to t = b, and the resulting estimates normalized to sum to the appropriate percentages of Table 13. This operation is displayed in Table 15.

Table 13

Households by Year Moved Into Unit

Year Moved in	Years at Address	Households	Percent
1958-Mar. 1960	0- 2	614	26.4%
1954 - 1957	3- 6	651	28.0
1940 - 1953	7-20	728	31.3
1939 or Before	21+	331	14.2
Total		2,324	100.1%

Source: U.S. Bureau of the Census, Census of Population and Housing: 1960, Census Tracts, Final Report PHC (1)-102, New Haven, Conn. SMSA, Table H-2, p. 4).

Table 14

Estimation of Interpolating Function for Duration of Residence

$$\log p(t) = -2.176 - .097 \cdot t$$

$(P < .01)(P < .01)$

R^2 (Population Estimate) = .96

Standard Error = .25

Degrees of Freedom = 2

Source: Regression on Table 13 data.

Table 15

Per Cent at Address by Year

At Address	Raw	Adjusted
≤1 Years	10.27	13.85
2	9.32	12.57
3	8.54	8.05
4	7.75	7.30
5	7.04	6.64
6	6.39	6.02

Source: Table 14 function applied yearly; results normalized to conform to Table 13.

The adjusted percentages from Table 15 were used to allocate households to years-at-address categories. This was done the same for each class of head and dwelling unit, since we had no information on how the distribution might vary across types.

An interesting sidelight is provided by the results of the estimation, which indicate a good fit of a negative exponential distribution to the data, even adjusting for the small degrees of freedom. If this result could be established more rigorously, it would imply that the decision to move might be modeled as a Poisson process.

Allocation of Outmigrants. Six categories of length of residence in Guilford were defined as follows: new immigrant (≤ 1 year of residence), resident 2, 3, 4, 5 and 6+ years. New immigrants by household type were estimated by the New Haven model. It was necessary to allocate the estimates of outmigrants to the resident 2, 3, 4, 5 and 6+ year categories. This process is diagramed in Figure 3.

In any year the difference in the number of households (ΔNH_i) for any household type (i) is increased by immigration ($IMIG_i$) and family formation ($NEWHH_i$), decreased by outmigration ($OMIG_i$) and family dissolution ($DEADNH_i$), and either increased or decreased by the aging of households (AGE_i), since age was used in the definition of household type.

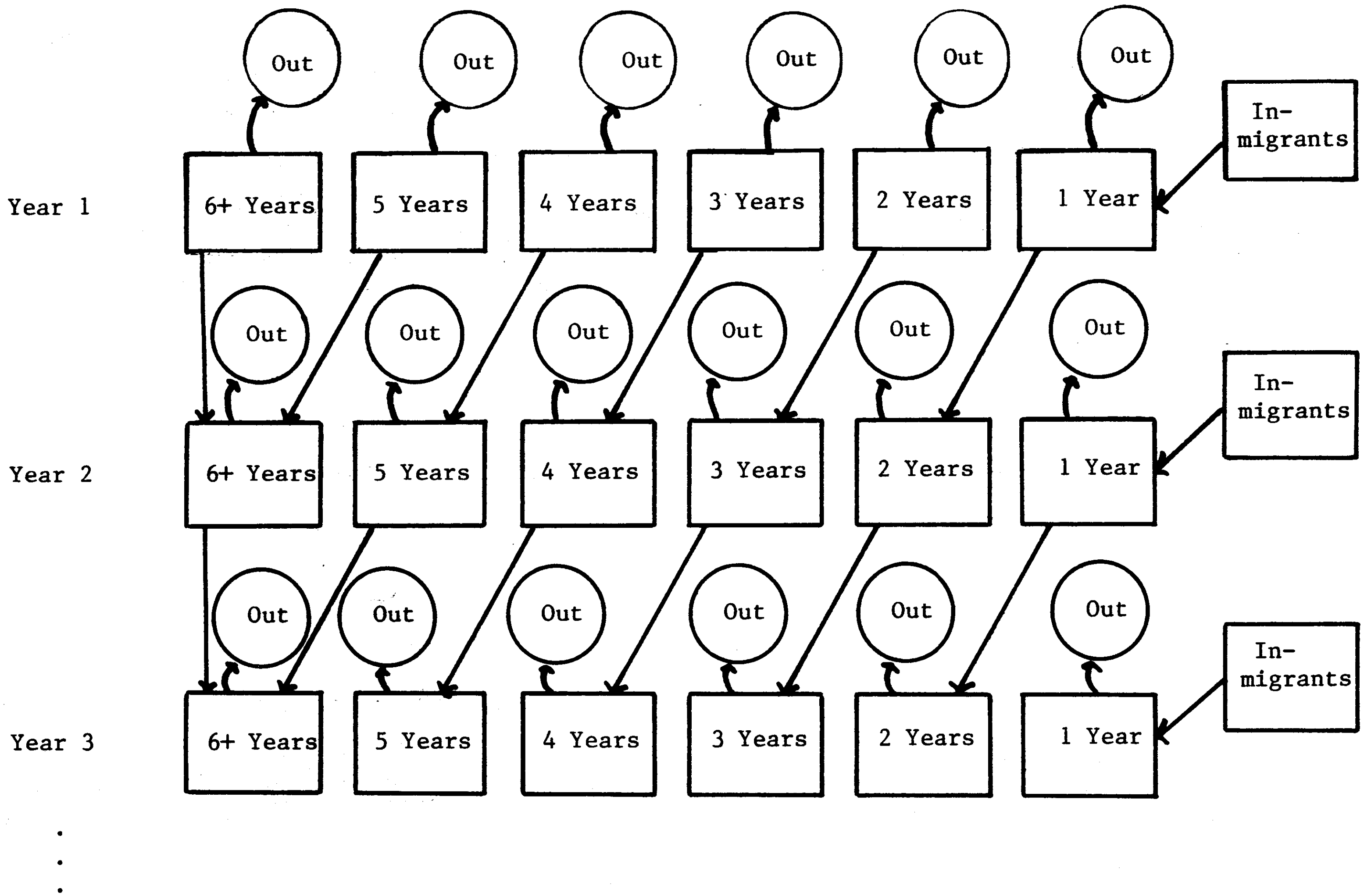

Figure 3

<u>Allocation of Outmigrants</u>

Thus the following identity holds:

$\Delta NH_i = IMIG_i - OMIG_i + NEWHH_i - DEADNH_i + AGE_i$. For this application immigrants and family formations were lumped together, as were outmigration and family dissolution.

Since the New Haven model estimated households by dwelling unit types (NH_{ij}) it was possible to calculate this difference (ΔNH_{ij}). Allocating immigrants and aging by the proportion of households found across dwelling units for each household type, and subtracting these quantities from ΔNH_{ij} yielded an estimate of outmigration by household and dwelling unit type. Thus,

$$(OMIG + DEADNH)_{ij} = NH_{ij} - \frac{NH_{ij}}{NH_{i.}} (IMIG_i + NEWHH_i + AGE_i).$$

It now remains to allocate, for each household-head/dwelling-unit type, the outmigrants to a years-at-address category, in order to properly decrement that category. There is very little research to aid in the specification of this process, however. The only solid evidence comes from the work of Morrison,[23] who estimated the probability of intercounty movement from Social Security data. His results indicated a high amount of "chronic mobility," i.e., the proportion of outmigrants who had been recent inmigrants was high. Although we had considerable reservations about the applicability of these findings to a suburban setting, his was the only source of data. The proportion outmigrating by duration of residence is displayed in Table 16.

[23] Peter A. Morrison, "Chronic Movers and the Future Redistribution of Population: A Longitudinal Analysis," Demography:8 #2(1971), pp.171-184.

Table 16

Proportion of Outmigration by Length of Prior Residence

Duration of Prior Residence	Proportion of Outmigration	Cumulative Proportion Staying
1	.234	.766
2	.191	.620
3	.166	.517
4	.126	.452
5	.091	.411

Source:

Column 2: Peter A. Morrison, "Chronic Movers and the Future Redistribution of Population: A Longitudinal Analysis," Demography: 8-2 (May, 1971), Table 3, p. 178.

Column 3: $C_j = \prod_{i=1}^{j} P_i$, where P_i is from column 2.

Outmigrants are selected from the populations at residence in the town for 1-5 years using the proportions shown in column 2 of Table The remainder are taken from those in residence 6+ years. If not all outmigrants have been accommodated with one iteration of this procedure, because the population at residence 6+ years cannot take up the slack, it is repeated until all outmigrants have been allocated to (subtracted from) a years-of-residence category. It should be noted that a household has only a .411 probability of surviving until 6+ years of residence if it is subject to this procedure in each of the five preceding years (see the last column of Table

Only two migration categories were employed in estimating numbers of children: 0-5 years of residence and 6+ years. This simplification was improved in order to greatly reduce the dimensionality required by the model, even though it thereby smoothed over the "peaking" effect of family size found above. Because of this simplification, numbers of households were aggregated into these two categories prior to the estimation of numbers of children.

Changing Number and Age Distribution of Children

Multiplying the number of households by type times the number of children by age for each household type provides one estimate of the number of children in town. It is not a particularly good estimate for several reasons. One obvious reason is that the numbers of children per family has been changing over time. Another is the tendency for the distribution by age to have shifted to older ages over time. Finally, our data on numbers of children were estimated from national rates, and Guilford is not necessarily representative of all suburban towns.

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[23] In practice, more than one iteration was rarely required.

Consequently, a series of time-varying factors were applied to the basic estimates. In the case of family size and age mix, the factors were developed from a comparison of 1960 and 1970 Census tabulations for Guilford. They were extended to 1980 by a comparison of national projections.

The number of children per household in Guilford increased from 1960 to 1970 while the distribution by age shifted to the school-aged years. Table 17 details the numbers of children by age grouping for each year, as well as the ratio of 1960 to 1970. In the actual application, the numbers of children in each age group were varied by a smooth function with each ratio as the starting point in 1960, passing through 1.0 in 1970, and extending to ratios consistent with current Census projections. Figure 4 displays the values these functions take from 1960 to 1980. Exponential functions were used to perform this interpolation, so that the functions would not increase without bound, although the results might not be appreciably different over the period we were simulating if a linear interpolation had been used.

For total family size, the 1960-70 ratio was used, but the 1970-80 ratio was assumed a constant 1.0. Since the Guilford family size had been increasing from 1960-70 while that for the U.S. had been declining, it did not seem sensible for the Guilford rate to follow the U.S. rate 1970-80.

Table 17

Numbers and Age Distribution of Children
Guilford, Conn.

Age	1960 (1)	1970 (2)	Ratio 1960/1970 (3)	Ratio 1980/1970 (4)	1980 (5)
0- 4	.414	.296	1.39	.95	.28
5	.075	.065	1.15	.92	.06
6-10	.328	.408	.805	.84	.34
11-14	.284	.340	.833	.84	.29
15-18	.190	.230	.826	.98	.23
19	.031	.035	.885	1.13	.04
Total	1.32	1.38	.958	.90	1.24

Sources:
Column 1 - U.S. Census, Census Tracts, ibid., Table P-2, p. 30.
Column 2 - U.S. Bureau of the Census, Census of Population and Housing: 1970, Census Tracts, Final Report PHC C1)-142 New Haven, Conn., SMSA (March, 1972), Table P-1, p. 6.
Column 3 - Column 1/Column 2
Column 4 - Martin M. Frankel and J. Fred Beamer, Projections of Educational Statistics to 1982-83: 1973 Edition, Department of Health, Education and Welfare, DHEW Pub. No. (OE) 74-11105 (1974), Tables B1 and B2, pp. 153-154, Census Series E (assumes cohort fertility = 2.1, reolacement level). Age 0-4 author's judgment. Total ratio of column 5 to column 2.
Column 5 - Column 2 x Column 4 for detailed ages. Total sum of detailed ages.

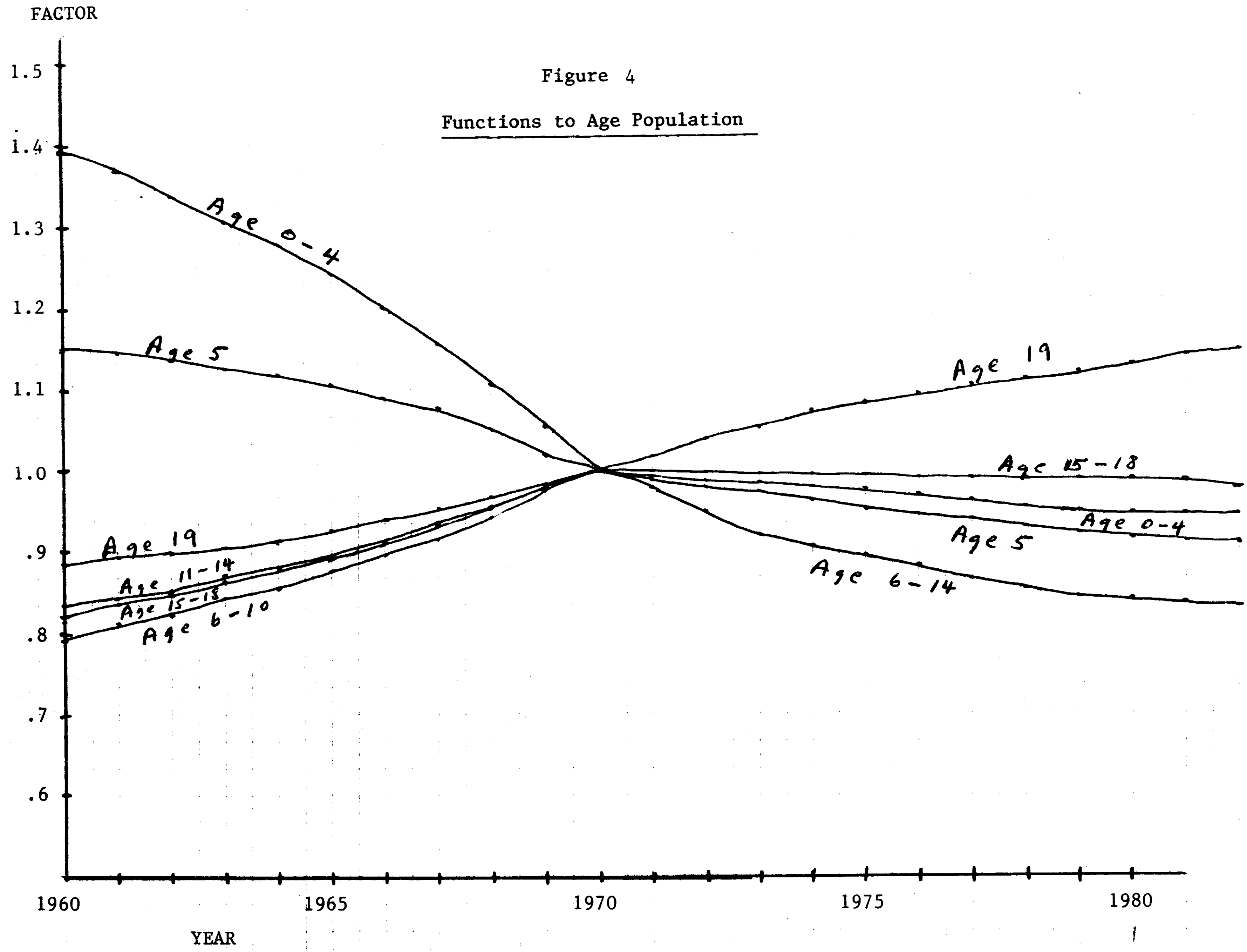


Figure 4

Functions to Age Population

TABLE 18

ESTIMATES OF CHILDREN WITHOUT MIGRATION FACTOR

REPORTS FOR YEAR 1960

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	828.	140.	701.	614.	563.	81.	2926.
ACTUAL	962.	173.	763.	659.	441.	72.	3070.
DIFFERENCE	-134.	-33.	-62.	-45.	122.	9.	-144.
PERCENT ERROR	-14.0	-19.2	-8.1	-6.9	27.6	11.8	-4.7

REPORTS FOR YEAR 1965

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1016.	182.	926.	769.	693.	110.	3695.

REPORTS FOR YEAR 1970

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1080.	235.	1397.	1102.	930.	141.	4885.
ACTUAL	1050.	247.	1446.	1204.	815.	123.	4885.
DIFFERENCE	30.	-12.	-49.	-102.	115.	18.	0.
PERCENT ERROR	2.8	-4.8	-3.4	-8.4	14.1	14.6	0.0

When this algorithm was used to estimate the total school-aged population of the town, it produced an overestimate of 18.7% of the 1970 population. Since we had no further Guilford-specific corrections to apply which could be derived from published data, it was assumed that this represented a deviation of Guilford from the nationally-estimated coefficients, and the results for all years were scaled by the reciprocal of 1.187.

The results of this procedure are displayed in Table 18. As can be seen, there is a tendency in both years to underestimate the numbers of younger children and to overestimate the numbers of older children. The most likely reason for this weakness, apart from errors in the inputs, is a misspecification of the probability of outmigration. Unfortunately, this is not a well-researched area, primarily due to the paucity of data, and the results upon which we based our work were for the probability of leaving the county --this of course includes much migration--and applies to all types of areas, not just movement from suburban towns. In light of the above results it seems much more likely that older residents are more likely to be the outmigrants, rather than the newer residents. Referring to the empirical results of a previous section, it can be seen that having a greater concentration of recent immigrants would tend to lower the average family size and produce a younger population of children.

A reformulation of the migration algorithm is a desirable next step. However, in order to proceed with the estimation, a time-varying adjustment, displayed in Figure 5, was made.

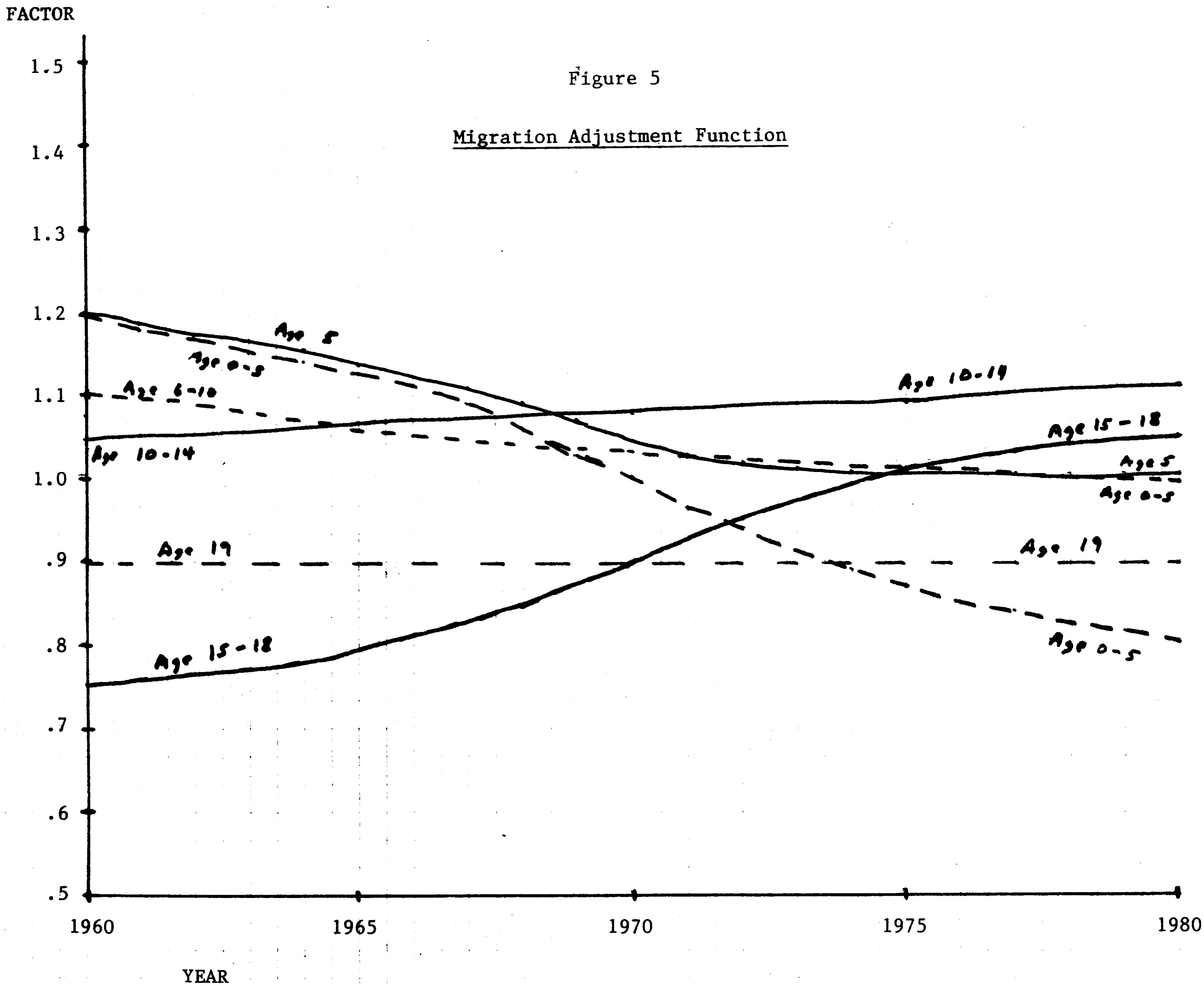


Figure 5

Migration Adjustment Function

This was done to correct for the under-representation of newer families and overrepresentation of older families. As can be seen from Figure 5, it varies least for the 6-10, 11-14, and 19 year old groups, following relatively gentle trends. For those less than 5 and 15-18, it is relatively larger. In a sense, it represents the error made by the algorithm in the past and that expected in the future. Since the choice of parameter values relies heavily on judgement, it must be considered one of the weakest parts of the procedure. Its use resulted in the estimates of children shown in Table 19.

Enrollments by Grade

Estimating numbers of children by age is only a first step in the estimation of public school enrollments. The actual enrollment process, as well as the assignment of children by age to enrollments by grade, must be accounted for.

There are two points at which a decision is made by parents concerning enrollment of their children in school. The first is whether or not to enroll the child at all. This decision is made by law in most jurisdictions, at least for the elementary and middle school years, and usually for high school as well. Kindergarten and below are typically optional.

Even if enrollment is mandatory, enrollment in a public school is not, and this would be expected to vary with the values of the household head. Certainly ethnicity is a good indicator of this, with Catholic families sending their children to parochial schools and Blacks typically utilizing public schools more. Higher education of head might predispose families to utilize private schools to a greater extent.

TABLE 19

ESTIMATES OF CHILDREN WITH MIGRATION FACTOR

REPORTS FOR YEAR 1960

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	993.	168.	757.	646.	422.	72.	3059.
ACTUAL	962.	173.	763.	659.	441.	72.	3070.
DIFFERENCE	31.	-5.	-6.	-13.	-19.	0.	-11.
PERCENT ERROR	3.3	-3.0	-0.8	-2.0	-4.4	0.7	-0.4

REPORTS FOR YEAR 1965

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1145.	208.	982.	818.	554.	99.	3805.

REPORTS FOR YEAR 1970

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1080.	247.	1439.	1190.	837.	127.	4920.
ACTUAL	1050.	247.	1446.	1204.	815.	123.	4885.
DIFFERENCE	30.	-0.	-7.	-14.	22.	4.	35.
PERCENT ERROR	2.8	-0.1	-0.5	-1.1	2.7	3.1	0.7

These are factors which are accounted for in the New Haven model, for which yearly estimates can be obtained, and which could be incorporated into the estimation method. There also seems to be a secular trend toward higher public school enrollment, which could be estimated and incorporated.

There are other factors, particularly those of a competitive nature, such as the cost and quality of education in both other towns and in the public versus the private sector. Additionally, the means of the inhabitants and their ability to take advantage of these opportunities may vary, and with it enrollment rates. Data on these factors were not available, however, and no consistent way of incorporating these effects was forthcoming.

The data for estimating the various rates again came from the 1970 Public Use Sample tapes for the Northeast. Again, it was felt important to exclude central city neighborhoods. In view of the hypothesis that a search for increased school quality is one possible component of suburbanization, we intended to utilize the Guilford sample, although this reduced the sample size considerably (from 11,500 to 6,000 children ages 0-19). If this hypothesis were true, one would expect a greater utilization of the suburban public schools -- families concerned with achieving a certain level of perceived education quality could vote either with their feet (and suburbanize) or their pocketbooks (and enroll their children privately). One would not expect them to do both.

One would expect that the rates of enrollment in public schools would be greatest in the Guilford-like sample, and lowest in the full sample, which had over 1/3 of the households in the central cities of urbanized areas. This is in fact the case, as can be seen from Table 20, which presents the enrollment rates for all households in each sample. Listed by grouping are: proportion enrolled in school (Enrolled); of those enrolled, the proportion enrolled in public school (In Public School); and the joint proportion enrolled in public school (Joint).

The Guilford and suburban samples are quite close in overall enrollment rates ages 6-18, and all ages have higher rates than the full sample. The Guilford sample does have a higher proportion of those enrolled in public schools, of those enrolled, and the suburban sample tends to be somewhat lower than the full sample. The pattern for those enrolled in public school (Joint) is for the Guilford sample to have the highest rates, followed by the suburban and full samples, although the differences are not large.

Enrollment by Household Type and Age of Child

For use in the model, the coefficients were tabulated by household type of head. Due to the extremely small number of children in the foreign, minority, and age 65 categories, only eight categories of households were employed.[25]

25

Age	Ethnicity	Education	Age	Ethnicity	Education
20-39	White Native Foreign and Minority	<, =, > HS All	40+	White Native Foreign and Minority	<, =, > HS All

Table 20

Enrollment Rates by Sample

Full Sample

Age	5	6-10	11-14	15-18	19	
Enrolled	.64	.97	.98	.89	.46	
In Public School	.85	.83	.84	.85	.61	
Joint	.54	.81	.82	.76	.28	
Numbers of Children	1424	7826	6388	5381	819	28,222

Suburban Sample

Enrolled	.69	.98	.99	.92	.52	
In Public School	.83	.82	.81	.83	.57	
Joint	.57	.81	.80	.76	.29	
Numbers of Children	513	3015	2513	2100	323	10,685

"Guilford-like" Sample

Enrolled	.64	.98	.98	.91	.50	
In Public School	.87	.84	.86	.88	.61	
Joint	.55	.82	.84	.79	.31	
Numbers of Children	613	3653	3010	2475	345	12,710

The coefficients from the Guilford sample were utilized. Since the selection criteria were low proportions of blacks and primary individuals and a high proportion of single family units, minorities and foreign born were obviously selected out, and both age categories had small numbers of cases. For this reason, the coefficients from the suburban sample were utilized for the foreign and minority categories. Table 21 details these rates.

As can be seen from the table, overall enrollment rates are not that different for older versus younger household heads of either ethnic grouping, except for the five and nineteen-year-old groups. For whites, there is a clear tendency for enrollment in public school to be higher for younger household heads. For foreign and minorities there is no across-the-board difference by age of head.

When white native household heads are further classified by education, there is a clear tendency for enrollments to increase with education of head. Enrollment in public school either is negatively sloped or U-shaped with respect to education. The negative slopes would be expected, since more highly educated parents would tend to value education more, and enroll their children privately to a greater extent. The U-shape does not support this hypothesis, however, and occurs for over one-third the age groups. Thus, a continuous approximation would not seem to be warranted in this case.

When it comes to the product of the two rates, the enrollments in public school (Joint), the effect of education is muted, since the tendency is for overall enrollments to increase with education of head, but public school enrollments do decline in many cases. The joint rates tend to reflect the public school enrollment rate pattern, since the overall enrollment rates are often close to one.

Table 21

Enrollment Rates by Age and Education of Heads

For Whites

(Guilford Sample)

Head White, Age 20-39, <High School

	Age of Children	5	6-10	11-14	15-18	19
1.	Enrolled	.55	.97	.97	.83	.35
2.	In Public School	.97	.90	.91	.94	1.0
3.	Joint (1 x 2)	.53	.87	.89	.78	.35
	Number of Children	105	623	350	134	17

Head White, Age 20-39, =High School

	Age of Children	5	6-10	11-14	15-18	19
1.	Enrolled	.59	.98	.98	.94	.43
2.	In Public School	.87	.84	.87	.97	.67
3.	Joint (1 x 2)	.51	.83	.86	.91	.29
	Number of Children	178	884	420	142	7

Head White, Age 20-39, >High School

	Age of Children	5	6-10	11-14	15-18	19
1.	Enrolled	.79	.99	.98	.95	.40
2.	In Public School	.83	.81	.85	.94	1.0
3.	Joint (1 x 2)	.66	.81	.83	.89	.40
	Number of Children	152	669	297	66	5

Table 21 (continued)

Enrollment Rates by Age and Education of Heads

For Whites

(Guilford Sample)

Head White, Age 40+, <High School

Age of Children	5	6-10	11-14	15-18	19
Enrolled	.47	.97	.98	.87	.44
In Public School	.93	.85	.90	.92	.66
Joint (1 x 2)	.44	.83	.88	.79	.29
Number of Children	64	469	632	753	121

Head White, Age 40+, =High School

Age of Children	5	6-10	11-14	15-18	19
Enrolled	.59	.99	.99	.92	.53
In Public School	.87	.79	.79	.85	.58
Joint (1 x 2)	.51	.78	.78	.79	.31
Number of Children	39	423	618	649	107

Head White, Age 40+, >High School

Age of Children	5	6-10	11-14	15-18	19
Enrolled	.73	.99	.99	.95	.65
In Public School	.75	.82	.85	.84	.45
Joint (1 x 2)	.55	.81	.85	.79	.29
Number of Children	49	433	561	600	65

Table 21 (continued)

Enrollment Rates by Age of Heads

Foreign and Minority Heads

(Suburban Sample)

Head Age 20-39

	Age of Children	5	6-10	11-14	15-18	19
1.	Enrolled	.72	.95	.99	.89	.71
2.	In Public School	1.00	.92	.91	.80	.40
3.	Joint (1 x 2)	.72	.88	.90	.71	.29
	Number of Children	36	.50	78	28	7

Head Age 40+

	Age of Children	5	6-10	11-14	15-18	19
1.	Enrolled	.71	.98	.96	.85	.44
2.	In Public School	.67	.90	.85	.84	.75
3.	Joint (1 x 2)	.47	.88	.82	.72	.33
	Number of Children	17	149	183	194	36

Age-to-Grade Mapping

Having estimated the numbers of children enrolled in school by age, the final problem is to translate numbers of children by age into numbers of children by grade. There is never a one-to-one mapping of children from age categories to grade. For example, while most of the 6-10 year olds attend elementary school, some may be in kindergarten and some in middle school. The same is true for the other age-grade combinations. Our approach was simple. Age-by-grade matrices for children enrolled in public school were tabulated from the Guilford-like sample, row normalized, and used in conjunction with the age vectors to map children by ages to children by grade. There is some variation by type of household head, and the tabulations are done for the same eight groups.

These matrices are displayed in Table 22. It should be noted that the diagonal elements are all fairly large -- i.e., the age categories correspond with the grades well, except for the middle school. In addition, this operation takes place upon children already enrolled in public schools -- in the model, there were few children age 19 enrolled in school, so this row has little meaning. There is not a large amount of variation among these matrices, although children of more highly-educated parents are somewhat less likely to be behind the modal grade for their age group.

Table 22

Age-to-Grade Mapping of Those Enrolled in Public School

(Guilford Sample)

Age 20-39 / White Native / < High School

Age of Children	Grade: Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	.963	.037	.000	.000	54
6-10	.089	.907	.004	.000	540
11-14	.000	.176	.708	.115	312
15-18	.000	.000	.058	.942	104
19	.000	.000	.000	1.000	5
Total Children	100	547	229	139	1015

Age 20-39 / White Native / = High School

Age of Children	Grade: Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	.921	.079	.000	.000	89
6-10	.071	.927	.001	.000	730
11-14	.000	.156	.733	.111	360
15-18	.000	.000	.031	.969	128
19	.000	.000	.000	1.000	1
Total Children	134	740	269	165	1308

Age 20-39 / White Native / > High School

Age of Children	Grade: Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	.990	.010	.000	.000	97
6-10	.085	.913	.002	.000	540
11-14	.000	.166	.749	.085	247
15-18	.000	.000	.035	.965	57
19	.000	.000	.000	1.000	1
Total Children	142	535	188	77	942

Table 22 (continued)

Age 20-39 / Foreign Born & Minority / All Grades

Age of Children	Grade Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	.900	.100	.000	.000	10
6-10	.100	.900	.000	.000	60
11-14	.000	.278	.722	.000	18
15-18	.000	.000	.000	1.000	9
10	.000	.000	.000	.000	0
Total Children	15	60	13	9	97

Age 40+ / White Native / <High School

Age of Children	Grade Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	1.000	.000	.000	.000	27
6-10	.070	.915	.016	.000	387
11-14	.000	.124	.727	.149	557
15-18	.000	.000	.041	.959	586
10	.000	.071	.071	.857	14
Total Children	54	424	436	657	1571

Age 40+ / White Native / = High School

Age of Children	Grade Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	.833	.167	.000	.000	18
6-10	.049	.945	.006	.000	328
11-14	.000	.098	.695	.207	482
15-18	.000	.002	.010	.988	489
19	.000	.000	.000	1.000	13
Total Children	31	361	342	596	1330

Table 22 (continued)

Age 40+ / White Native / > High School

Age of Children	Grade: Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	.963	.037	.000	.000	27
6-10	.054	.929	.017	.000	351
11-14	.000	.071	.731	.197	476
15-18	.000	.004	.007	.989	453
19	.000	.000	.000	1.000	1
Total Children	45	363	357	543	1308

Age 40+ / **Foreign** Born & Minority / All Grades

Age of Children	Grade: Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	1.000	.000	.000	.000	6
6-10	.016	.969	.016	.000	64
11-14	.000	.101	.759	.139	79
15-18	.000	.013	.026	.961	77
19	.000	.000	.000	1.000	4
Total Children	7	71	63	89	230

Total Households

Age of Children	Grade: Kindergarten	Elementary (1-5)	Middle (6-8)	High (9-12)	Children Total
5	.954	.046	.000	.000	328
6-10	.072	.922	.006	.000	3000
11-14	.000	.124	.723	.152	2531
15-18	.000	.002	.024	.974	1903
19	.000	.026	.026	.949	39
Total Children	528	3101	1897	2275	7801

Estimating Enrollments

Having estimated the numbers of school-aged children, it is then necessary to apply the enrollment rates discussed above to estimate enrollments by age. This is very straightforward, except that enrollment rates, particularly in the higher grades, have been increasing over time.

A difficulty with this portion of the algorithm is the form of the enrollment functions. The points in 1970 were given. In addition, the ratio of the public school enrollment actuals over time to the estimates of total children in the applicable age group could be calculated. The problem lay in that the various enrollment rates needed -- by age -- were not available at the local or national level.

As a compromise, the ratios of national enrollments in grades 9-12 to total children ages 14-18, as well as public school enrollments to total enrollments were examined for 1960 and 1970, as displayed in Table 23. The growth in these series was about half what was required to account for the change in Guilford enrollments, however, and a higher rate of change was assumed for each series in the model, as is displayed in Table 23.

For the middle- and high-school aged groups, time-varying functions which passed through the appropriate rate in 1970 were introduced for total enrollments and public-school enrollments for each of the eight household head types. An example of one such rate is given in Figure 6. All household types and grades are not shown for reasons of space. The same general shape of the curve was assumed for both the middle and high-school aged groups, although the midpoint in 1970 depended on the data presented in Table 21.

Table 23

Changes in High School Enrollment Rates

1962 - 1970

Total Enrollments / Children 14-18	1962	1970	Ratio
U.S.*	.73	.74	1.014
Model**	.88	.91	1.034
Public / (Public + Private)			
U.S.*	.89	.91	1.022
Model**	.85	.88	1.035

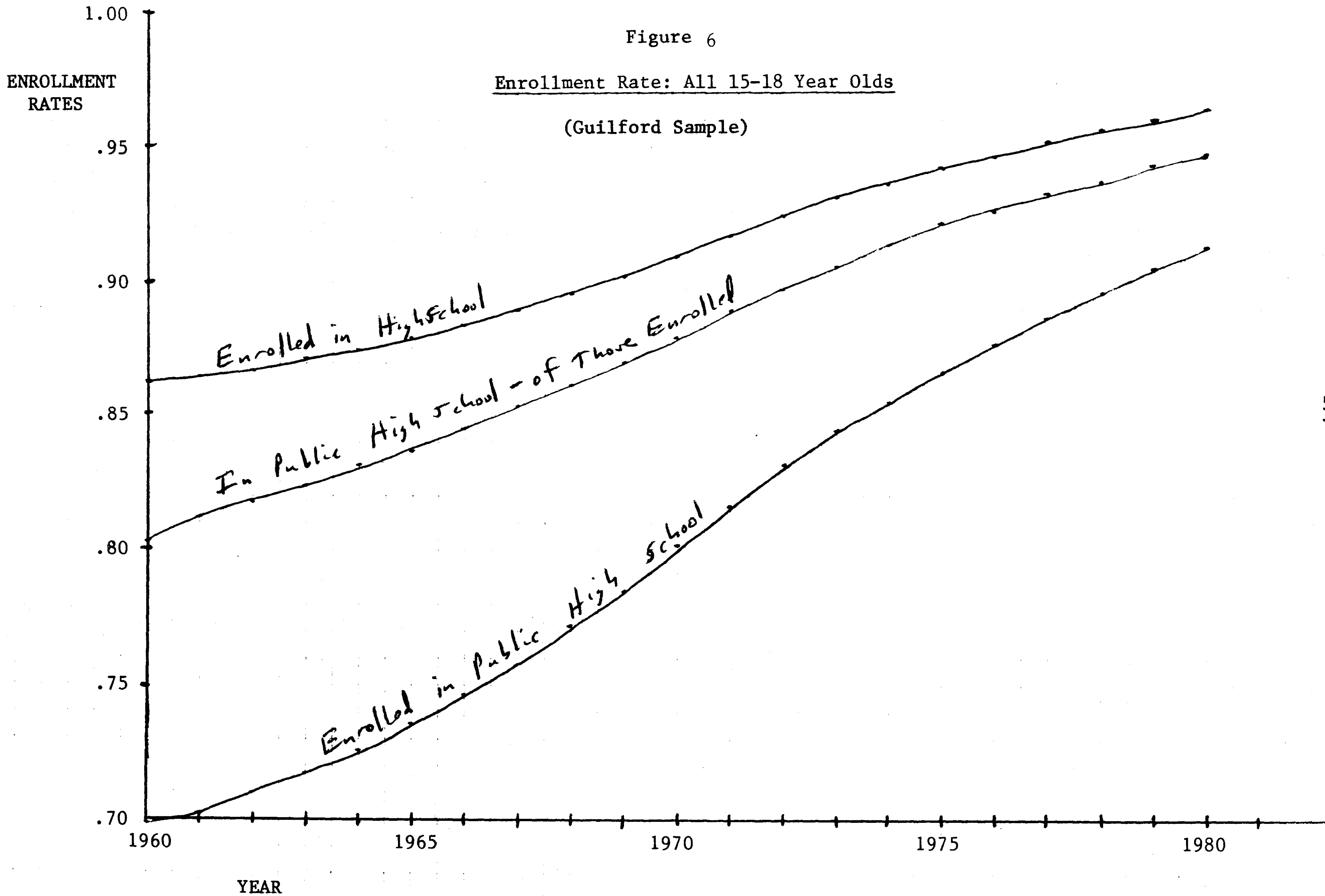
* Source: Frankel and Beamer, Projections of Educational Statistics, op. cit., Table B-2, p. 154, and Table B-3, p. 155.

** The rate with the total "Guilford Sample" rates substituted (see Table 20), for comparison with the U.S. rates only. In practice, the rates were disaggregated by type of household head, as in Table 21.

Figure 6

Enrollment Rate: All 15-18 Year Olds

(Guilford Sample)



The 6-10 year-old rates were judged applicable to Guilford and remained constant over time. However, the rates estimated from the national data for the 5- and 19-year old age groups did not correspond with the local experience. The kindergarten enrollment rates described above were too low based on a comparison of Census age data with actual kindergarten enrollments, so this rate was set at a constant .98 (Total and Public Enrollments both .99). Enrollment of 19-year olds was considered very low by the Superintendent of Schools, and we set this rate to a constant .038 (Total Enrollment = .05, Public Enrollment = .75).

Following the enrollment estimation, it was necessary to apply the age-to-grade mapping matrices in order to translate from enrollments by age to enrollments by grade. This was simply a matrix multiplication of the age-to-grade matrices times the enrollment-by-age vectors for each household type. Because of local experience and policies, all eligible 5-year olds were enrolled in kindergarten and no 19-year olds were permitted to enroll in the middle school in the model. Elementary enrollments were considerably too low by this procedure, and they were scaled by a constant so as to pass through the 1970 enrollment figure.

The estimates which result from the application of the steps described in the previous sections are displayed for the years 1960-1973 in Table 4 above.

Summary of the Algorithm

The algorithm itself is summarized below in the form of the equations which are employed to implement it.

Notation.

$_{\ell}C^{t}_{gijkm}$	Number of children	
	t = time	t = 1960...1980
	g = age group	g = 1...6
	i = household type	i = 1...27
	j = tenure (own/rent)	j = 1...2
	k = price of unit	k = 1...3
	l = stage of estimation	l = 1...2
	r = grade in school	r = 1...4
	m - length of residence	m = 1...2
$F(t)$	Family size variation at time t	
$R_g(t)$	Function to adjust age mix over time	
H^t_{ijkm}	Numbers of households of type i,j,k,m at time t	
K^t_{gi}	Numbers of children by age and household type at t	
$T_g(t,M)$	Function to vary enrollment rates over time	
M^{1970}_{gi}	Enrollment rates in 1970 by age and household type	
E^t_{gi}	Number of children enrolled by age and household type at time t	
$S_g(t,N)$	Function to vary public school enrollment rate over time	
N^{1970}_{gi}	Public school enrollment rates in 1970 by age and household type	
D^t_{gi}	Public school enrollments by age and household type at t	
A_{pgi}	Age-to-grade mapping matrix by household type	
G^t_{ri}	Public school enrollments by grade and household type at time t	
$Q_g(t)$	Function to adjust age mix for migration over time	
B^{1970}	Constant - Guilford versus estimate in 1970 - Total Children	

Number of Children.

The basis for the estimation method is a matrix of numbers of children by age of child by type of household dwelling unit and migration status estimated from 1970 data. This matrix, C^{1970}_{gijkm} is then adjusted so that total family size as well as the mix by age is correct for year t.

Change Age Mix.

In the first step the mix of children by age is adjusted, so that there is a greater proportion of younger children before 1970, and older afterwards.

$$ {}_1C^{t}_{gijkm} = C^{1970}_{gijk} \cdot R_g(t) \cdot Q_g(t) $$

Adjust Family Size.

Next, family size is adjusted by a time-varying factor.

$$ {}_2C^{t}_{gijk} = {}_1C^{t}_{gijkm} \cdot F(t) $$

Estimate Numbers of Children.

Using this updated age matrix and the matrix of numbers of households, an estimate of numbers of children by age is formed.

$$ K^{t}_{gi} = \sum_{i=1}^{27} \sum_{j=1}^{2} \sum_{k=1}^{3} \sum_{m=1}^{2} H^{t}_{ijkm} \cdot {}_2C^{t}_{gijkm} \cdot B^{1970} $$

Estimate Total Enrollment.

Enrollment rates for both public and private schools in 1970 by age and household type are adjusted by a time-varying factor and applied to numbers of children to derive total enrollments.

$$ E^{t}_{gi} = K^{t}_{gi} \cdot T_g(t, M^{1970}_{gi}) $$

Estimate Public Enrollments.

A similar procedure adjusts the 1970 rates of public school enrollments for those in school.

$$D_{gi}^{t} = E_{gi}^{t} \cdot S_g \; (t, N_{gi}^{1970})$$

Age-to-Grade Mapping.

Enrollees by age are mapped into enrollees by grade by a simple matrix multiplication.

$$G_{ri}^{t} = \sum_{g=1}^{6} A_{rgi} \cdot D_{gi}^{t}$$

Summary

Education expenditures, both capital and recurring, are the single most important part of the budgets of towns, particularly those in the suburban ring, where they constitute over one-half of all expenditures. Costs are rising, and, although birth rates are dropping nationally, the pressure on suburban towns may well not let up, due to the locational aspect of growth. For these reasons, we have concentrated considerable attention on the estimation of numbers of school children.

Current methods tend to be simple extrapolations of trends, for the most part, and are particularly weak in areas of rapid growth or decline. By the use of a model of the exchange of households between the region as a whole and the town, it was possible to estimate school enrollments over time, utilizing a great deal of disaggregation of rates of children by age, household and dwelling unit type, and rates of enrollment over time. National rates were adapted for local use by a variety of means, and ways of changing them over time were devised. The importance of this disaggregation was underscored by the wide variation which was found in the number and age distribution of children by characteristics of the head of the household, dwelling unit type, and migration status of the household.

Without the use of the New Haven model or the disaggregation which it allowed, the estimation of enrollments would have been much less sensitive to changes in both in and out-migration of households and the attendent changes in the "mix" of determinants. Even at that, the accounting for households by migration status seemed to be the weakest part of the procedure, and one which necessitated a fairly arbitrary correction.

Chapter 6

Town Budget Estimation

Chapter 3 discussed two conceptualizations of the town budgeting process -- the internally-determined, intra-organizational view and the externally determined, "environmental" view. Rather than being competing theories, each view was seen as applicable in a different situation. Where spending priorities are constant, demands for service are not in conflict with these priorities, the capacity for debt financing is unimpaired, and tax rates can be set so as to balance the budget, demands for service would be expected to be translated fairly directly into expenditures. On the other hand, if one or more of the above conditions are not met, the availability of resources to meet demands would become problematic, and intra-organizational processes of negotiation, conflict resolution and coordination would increasingly affect the resource-allocation process in significant ways not directly related to external demands.

This distinction has important implications for modeling the budgeting process. Where the environmental view is appropriate, the internal organizational dynamics may be safely ignored, or equivalently, may be assumed constant with respect to the demand relationships. Where this view is not appropriate, the internal dynamics of the organization must be explicitly incorporated into the model in order to capture a significant aspect of change. Except in the cases of a static environment, the determinants of demand must, by contrast, always be represented.

In this study, it is assumed that the environmental view is a valid representation and that intra-organizational dynamics may be ignored. It is thus assumed that external demands are directly related to expenditures and that the community under study taxes to the extent necessary to balance its budget. For the community under study it is a reasonably safe assumption because community composition, priorities for spending, willingness to be taxed, and continued capacity for debt financing are more or less constant.

The community composition has been relatively stable from 1960-1970, when measured by age, ethnicity, or educational attainments, although changes have been occurring slowly. The age distribution has gradually become younger and better educated, with a shrinking percentage of foreign-born households, a rising percentage of minorities and white natives (see Tables 1 and 2). Estimates from a "base case" run of the New Haven model (see below) indicate a continuation of these trends to 1980, except for a leveling off of the proportion white native.

This has several effects which simplify the analysis. One, we assume that the priorities for spending are constant from the point of view of what residents value — schools will continue to be viewed as important, as will the provision of amenities. In addition, we do not foresee an influx of households who would place radically different demands upon the school, police, or welfare functions, and upset the existing balance of priorities via the "External Demands" route.

Several other external influences which could have upset the balance have been resisted by the town. A proposed racetrack was defeated. This would have produced a great deal of tax revenue, but would have demanded a greater emphasis on police protection and roads, and might have changed the mix of

Table 1

Distribution of Households by Age, Ethnicity, and Education of Head
Guilford, Conn.

Year	1960	1970	1980
Age			
20-39	34.2	36.0	39.6
40-64	47.3	47.6	46.2
65+	18.5	16.4	14.3
Ethnicity			
Native white	89.1	92.9	91.8
Foreign	9.8	4.6	3.3
Minority	1.0	2.5	4.9
Education			
< High School	40.8	34.3	26.6
= High School	27.0	23.5	27.2
> High School	32.1	42.2	46.2
Total Households	2321	3582	5551

Source: New Haven model, 1960 and 1970 are actuals, 1980 is a "base case" simulation.

Table 2

Distribution of Households by Age and Ethnicity of Head Jointly
Guilford, Conn.

Age	Ethnicity	1960	1970	1980
20-39	Native white	32.9%	34.4%	36.5%
	Foreign & minority	1.3	1.7	3.0
40-64	Native white	42.7	44.4	42.5
	Foreign & minority	4.6	3.2	3.17
65+	Native white	13.5	14.1	12.8
	Foreign & minority	5.0	2.3	1.4
Total Households		2321	3582	5551

Source: New Haven model. 1960 and 1970 are actuals. 1980 is a "base case" simulation.

immigrants. Locating a proposed bridge across the Long Island Sound in Guilford has also been resisted. This might well cause an explosion of growth of an unpredictable nature and would certainly change the character of the tax base and possibly of the supporting public works as well. Both proposals would affect the town in nonfiscal ways as well, of course, radically changing the amenities and character of the town and perhaps the political process.[1]

Due to the stability of the population mix, their willingness to be taxed is assumed not to be a binding constraint. Additionally, the tax rate is not excessive and some leeway for the future is assumed.

Likewise, the town is currently in good shape in terms of its indebtedness, which was only 22% of that permitted by law in the 1971-1972 fiscal years, and experiences little trouble in raising money.

Due to these factors, it is not anticipated that potential deficits which serve to maintain existing service levels will feed back to change priorities for spending or to lower expenditures.

Since Connecticut does not have "circuit breaker" or other aid arrangements which determine level of aid as a function of effort and need, this source of feedback is ignored.[2]

Finally, community attitudes toward industry are not expected to change.

This leaves us with an essentially demand-driven system in which demands are translated into expenditures, and the difference between these required expenditures minus available revenue from local user charges, state and federal aid is covered by the property tax. This leaves us with a fairly straightforward problem of conceptualization and estimation.

[1]Background for these comments came from an interview with Guilford Head Selectman, H. Waugh, October 1973.

[2]See David S. Stern, "The Effects of Alternative State Aid Formulas in the Distribution of Public School Expenditures in Massachusetts", unpublished Ph.D dissertation, M.I.T., Department of Urban Studies and Planning, January 1972, for an excellent study of the alternative effects of different state aid formulas for schools in Massachusetts.

Budget Structure

The structure is essentially an elaboration of that illustrated in Figure 1 of Chapter 3. External demands are translated without constraints into expenditures. Revenues other than from the property tax are also related directly to exogenous variables. The base of taxable property consists of residential, commercial, and industrial property. The tax rate is the ratio of expenditures to the tax base. The requirements for debt funding are determined by demand factors.

In order to better predict expenditures and revenues, these categories were broken down into components which were judged to be homogeneous in composition, and hopefully, in terms of their determinants as well. It was not practical to work with all the line items of the budget separately, since there were so many of them and many of the dollar amounts were quite small.

Chart 1 defines each model category of expenditure and revenue in terms of its components in the Guilford town budget. Expenditures were divided into categories as follows: school budget, debt service, normal capital expenditures, health-welfare-recreation, maintenance, public safety, town administration (essentially an "all-other" category).

The revenue categories were grouped by level of government. No attempt was made to predict federal revenues. Although the local and state revenue categories were quite heterogeneous in composition, it was still possible to estimate the relationships satisfactorily, as detailed below.

The budget process in Guilford in terms of these categories is illustrated in Figure 1 below. We will discuss it in general terms in this section, then proceed to the more technical details in the following sections.

Chart 1

Budget Categories & Sources for Town of Guilford

Revenue

Taken from "General Fund - Statement of Revenues - Compared with Budget Estimates". Actual revenues used.

Model Category	Statement Category
Property Tax	Property taxes
State	Board of Education - state Building grants - state Miscellaneous - state Highway grant - state Supplemental revenue - Board of Education - state (Fy71) Public School Building Grants (Fy63)
Federal	Housing & Urban Development (Fy69)
Local	Local departmental Board of Education - local Interest on short-term investments Supplemental revenue - recreation (Fy70) School Construction (Fy63)

Expenditures

Taken from "General Fund - Statement of Appropriations and Expenditures". Expenditures used.

Model Category	Statement Category
Schools	Board of Education - Board's Report
Maintenance	Public Works State Aid - Highway Maintenance Town Hall Maintenance
Debt Service	Interest and Debt Retirement
Normal Capital	Capital Outlay Library Expansion Reserve Fund of Capital and Nonrecurring Expenditures

Expenditures, cont.

Public Safety	Police Department Fire Department Hydrant Rental Civil Defense Dog Damage Communication
Health, Welfare & Recreation	Recreation and Park Commission Sewer Authority Guilford Memorial Association Public Health Nurses Association Welfare Public Library Conservation Commission Marina Commission Department of Health Social Services
Town Administration*	Board of Selectmen Town Clerk Treasurer Board of Finance Registrar of Voters Insurance Employee Benefits Town Counsel Annual Audit Engineering Assessor Board of Tax Review Tax Collector Central Clerical Planning & Zoning Commission Zoning Board of Appeals Data Processing Probate Court Industrial Development Commission

* This category is the "residual", which includes everything not included above. In 1972, it was composed of the listed categories.

Source: Annual Report, Guilford, Connecticut, 1960-1961 to 1971-1972.

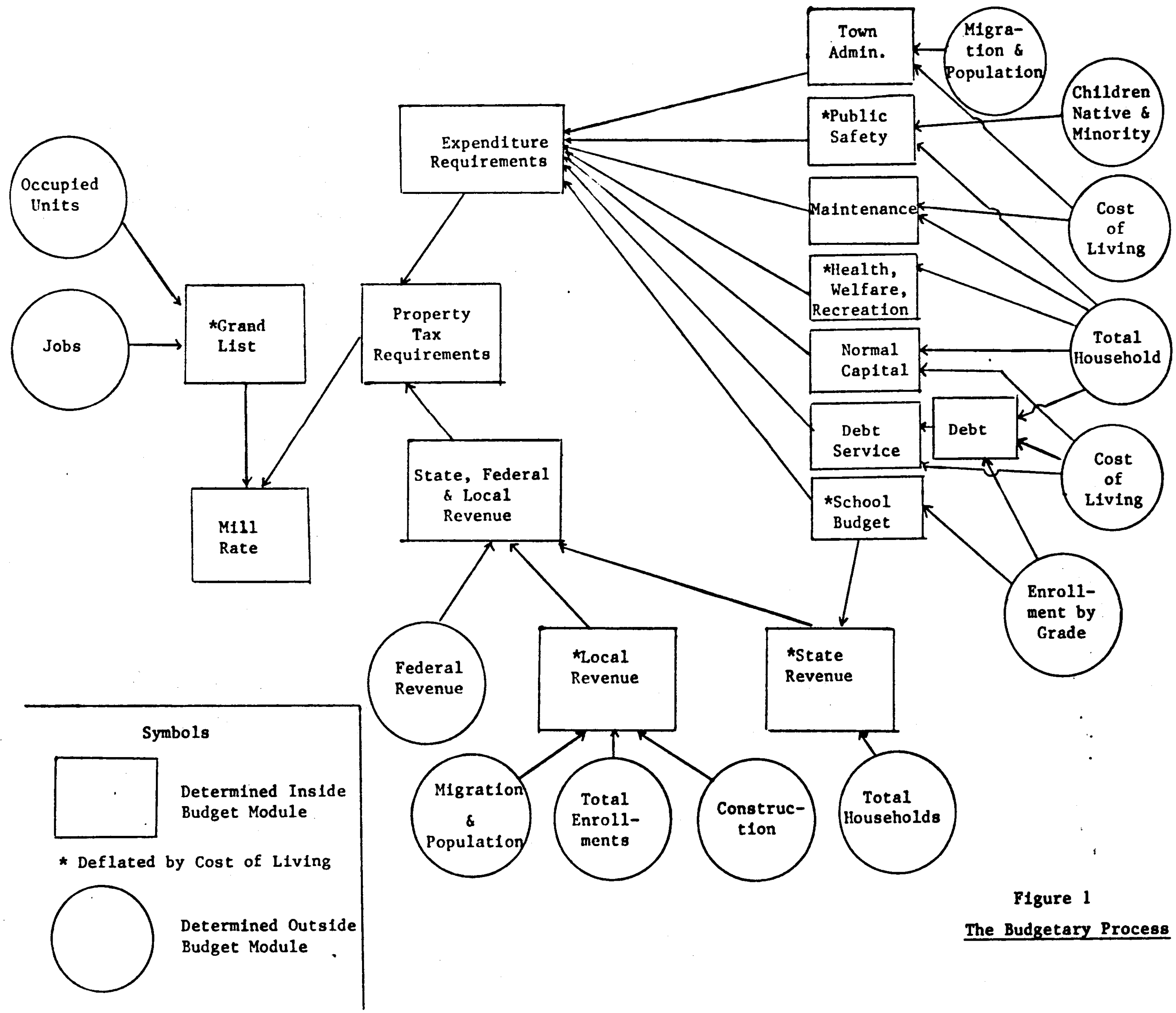


Figure 1

The Budgetary Process

In the figure, those quantities which are estimated in this chapter, such as expenditure or revenue items, are represented by boxes. Those quantities determined outside this chapter, such as school enrollments, cost of living, numbers of households, etc., are represented by circles. Federal revenues are taken directly from the actual figures for the historical time period and assumed zero thereafter. Cost of living is taken directly from the Bureau of Labor Statistics' annual national index. Enrollment by grade is estimated from New Haven model inputs and other factors, as discussed in the previous chapter. All other quantities are estimated by the New Haven model.

The process is as follows. Expenditures are determined by the factors conceived as important for each item. Each item has its own determinants. Debt requirements are determined in the same manner, and influence debt service costs. Local and state revenues are determined independently, but with reference to some of the same factors. The Grand List of taxable property is determined by estimates of residential, commercial and industrial property.

Property tax revenues and the mill rate are determined in the following manner. The expenditure requirements category is the sum of each expenditure item. The requirement from the property tax is then these expenditure requirements less federal, state and local revenues. The mill rate is simply the ratio of property tax requirements to the Grand List.

As can be seen, the structure is fairly simple — there are relatively few determinants for each item. In addition, the mill rate is not directly estimated but is derived from the other estimates. Nonetheless, each item, including the mill rate, follows its historical pattern fairly well. The agreement of the estimated totals with the actual figures is even closer. Table 3 on the following pages compares the predictions from the model with the actual figures from the town report.

Table 3

<u>Town Budget Estimates</u>

REPORTS FOR YEAR 1961

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	1.214	1.203	0.011	0.9
STATE	0.259	0.258	0.001	0.4
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.030	0.040	-0.010	-25.3
TOTAL S,F,L	0.289	0.298	-0.009	-3.0
TOTAL REVENUE	1.503	1.500	0.002	0.1
EXPENDITURES:				
SCHOOLS	0.750	0.795	-0.045	-5.7
MAINTENANCE	0.159	0.155	0.004	2.7
DEBT SERVICE	0.244	0.243	0.001	0.4
NORM. CAPITAL	0.052	0.051	0.001	2.4
TOWN ADMIN.	0.135	0.133	0.002	1.7
PUBLIC SAFETY	0.111	0.115	-0.004	-3.4
HLTH/WLFR/RCN	0.053	0.055	-0.003	-4.7
TOTAL EXPEND.	1.503	1.546	-0.043	-2.8
TOTAL DEBT	2.019	2.161	-0.142	-6.6
MILL RATE	0.031	0.029	0.002	5.9
GRAND LIST	39.532	41.608	-2.076	-5.0

REPORTS FOR YEAR 1962

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	1.321	1.291	0.030	2.3
STATE	0.310	0.342	-0.032	-9.2
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.040	0.045	-0.005	-10.9
TOTAL S,F,L	0.351	0.387	-0.036	-9.4
TOTAL REVENUE	1.672	1.678	-0.006	-0.4
EXPENDITURES:				
SCHOOLS	0.876	0.883	-0.007	-0.8
MAINTENANCE	0.162	0.154	0.007	4.8
DEBT SERVICE	0.252	0.244	0.008	3.2
NORM. CAPITAL	0.045	0.046	-0.001	-1.6
TOWN ADMIN.	0.147	0.127	0.021	16.4
PUBLIC SAFETY	0.126	0.129	-0.002	-1.8
HLTH/WLFR/RCN	0.063	0.064	-0.001	-2.2
TOTAL EXPEND.	1.672	1.647	0.025	1.5
TOTAL DEBT	2.122	2.030	0.092	4.5
MILL RATE	0.030	0.030	0.000	1.6
GRAND LIST	43.693	43.457	0.237	0.5

REPORTS FOR YEAR 1963

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	1.401	1.352	0.049	3.6
STATE	0.374	0.376	-0.003	-0.7
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.055	0.049	0.006	12.5
TOTAL S,F,L	0.429	0.425	0.003	0.8
TOTAL REVENUE	1.830	1.777	0.052	3.0
EXPENDITURES:				
SCHOOLS	1.022	0.957	0.066	6.9
MAINTENANCE	0.164	0.174	-0.010	-5.7
DEBT SERVICE	0.256	0.249	0.007	2.9
NORM. CAPITAL	0.036	0.044	-0.008	-17.6
TOWN ADMIN.	0.130	0.130	-0.000	-0.2
PUBLIC SAFETY	0.145	0.141	0.004	2.8
HLTH/WLFR/RCN	0.075	0.077	-0.002	-2.0
TOTAL EXPEND.	1.830	1.772	0.058	3.3
TOTAL DEBT	2.159	1.929	0.230	11.9
MILL RATE	0.029	0.030	-0.001	-3.3
GRAND LIST	48.706	45.425	3.281	7.2

REPORTS FOR YEAR 1964

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	1.422	1.472	-0.050	-3.4
STATE	0.438	0.416	0.022	5.2
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.069	0.053	0.016	30.2
TOTAL S,F,L	0.507	0.469	0.038	8.0
TOTAL REVENUE	1.929	1.942	-0.012	-0.6
EXPENDITURES:				
SCHOOLS	1.121	1.049	0.072	6.9
MAINTENANCE	0.168	0.172	-0.003	-2.0
DEBT SERVICE	0.262	0.281	-0.018	-6.6
NORM. CAPITAL	0.029	0.021	0.008	38.3
TOWN ADMIN.	0.175	0.154	0.022	14.0
PUBLIC SAFETY	0.165	0.164	0.000	0.2
HLTH/WLFR/RCN	0.009	0.009	-0.000	-0.6
TOTAL EXPEND.	1.929	1.928	0.002	0.1
TOTAL DEBT	2.233	2.343	-0.109	-4.7
MILL RATE	0.026	0.031	-0.005	-14.6
GRAND LIST	53.726	47.540	6.186	13.0

REPORTS FOR YEAR 1965

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	1.526	1.642	-0.116	-7.0
STATE	0.494	0.458	0.036	7.8
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.080	0.059	0.021	34.9
TOTAL S,F,L	0.574	0.517	0.057	10.9
TOTAL REVENUE	2.100	2.159	-0.059	-2.7
EXPENDITURES:				
SCHOOLS	1.192	1.201	-0.009	-0.7
MAINTENANCE	0.174	0.184	-0.010	-5.4
DEBT SERVICE	0.274	0.269	0.004	1.5
NORM. CAPITAL	0.027	0.029	-0.003	-8.7
TOWN ADMIN.	0.154	0.183	-0.030	-16.2
PUBLIC SAFETY	0.181	0.174	0.008	4.5
HLTH/WLFR/RCN	0.099	0.100	-0.001	-0.9
TOTAL EXPEND.	2.100	2.140	-0.040	-1.9
TOTAL DEBT	2.365	2.167	0.198	9.2
MILL RATE	0.026	0.025	0.001	2.1
GRAND LIST	58.625	64.461	-5.836	-9.1

REPORTS FOR YEAR 1966

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	1.706	1.777	-0.070	-4.0
STATE	0.551	0.595	-0.044	-7.4
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.090	0.126	-0.036	-28.7
TOTAL S,F,L	0.641	0.721	-0.080	-11.1
TOTAL REVENUE	2.347	2.498	-0.151	-6.0
EXPENDITURES:				
SCHOOLS	1.340	1.394	-0.053	-3.8
MAINTENANCE	0.187	0.208	-0.021	-10.2
DEBT SERVICE	0.314	0.310	0.005	1.5
NORM. CAPITAL	0.033	0.029	0.005	16.2
TOWN ADMIN.	0.164	0.187	-0.023	-12.3
PUBLIC SAFETY	0.199	0.195	0.003	1.7
HLTH/WLFR/RCN	0.110	0.110	-0.001	-0.5
TOTAL EXPEND.	2.347	2.433	-0.086	-3.5
TOTAL DEBT	2.906	3.341	-0.435	-13.0
MILL RATE	0.027	0.026	0.000	0.5
GRAND LIST	64.061	67.178	-3.117	-4.6

REPORTS FOR YEAR 1967

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	2.006	1.997	0.010	0.5
STATE	0.617	0.574	0.042	7.4
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.101	0.087	0.014	16.6
TOTAL S,F,L	0.718	0.661	0.057	8.6
TOTAL REVENUE	2.724	2.658	0.066	2.5
EXPENDITURES:				
SCHOOLS	1.559	1.574	-0.015	-0.9
MAINTENANCE	0.199	0.182	0.017	9.4
DEBT SERVICE	0.355	0.325	0.030	9.3
NORM. CAPITAL	0.066	0.066	-0.000	-0.0
TOWN ADMIN.	0.204	0.205	-0.000	-0.1
PUBLIC SAFETY	0.218	0.221	-0.003	-1.2
HLTH/WLFR/RCN	0.123	0.106	0.016	15.2
TOTAL EXPEND.	2.724	2.678	0.046	1.7
TOTAL DEBT	3.439	3.300	0.139	4.2
MILL RATE	0.029	0.028	0.001	2.5
GRAND LIST	69.921	71.346	-1.425	-2.0

REPORTS FOR YEAR 1968

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	2.278	2.312	-0.035	-1.5
STATE	0.704	0.718	-0.014	-2.0
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.118	0.113	0.004	3.8
TOTAL S,F,L	0.822	0.832	-0.010	-1.2
TOTAL REVENUE	3.099	3.144	-0.045	-1.4
EXPENDITURES:				
SCHOOLS	1.834	1.838	-0.004	-0.2
MAINTENANCE	0.218	0.205	0.014	6.8
DEBT SERVICE	0.342	0.368	-0.025	-6.9
NORM. CAPITAL	0.052	0.050	0.002	4.7
TOWN ADMIN.	0.267	0.244	0.023	9.3
PUBLIC SAFETY	0.245	0.253	-0.008	-3.0
HLTH/WLFR/RCN	0.140	0.121	0.018	15.1
TOTAL EXPEND.	3.099	3.079	0.020	0.7
TOTAL DEBT	3.187	3.190	-0.003	-0.1
MILL RATE	0.030	0.031	-0.001	-2.2
GRAND LIST	76.320	75.868	0.452	0.6

REPORTS FOR YEAR 1969

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	2.732	2.746	-0.014	-0.5
STATE	0.817	0.790	0.027	3.4
FEDERAL	0.000	0.046	-0.046	-100.0
LOCAL	0.140	0.149	-0.009	-6.2
TOTAL S,F,L	0.956	0.985	-0.029	-2.9
TOTAL REVENUE	3.689	3.731	-0.043	-1.1
EXPENDITURES:				
SCHOOLS	2.239	2.142	0.096	4.5
MAINTENANCE	0.245	0.220	0.025	11.4
DEBT SERVICE	0.546	0.559	-0.013	-2.3
NORM. CAPITAL	0.006	0.006	-0.000	-1.3
TOWN ADMIN.	0.346	0.394	-0.049	-12.4
PUBLIC SAFETY	0.146	0.146	-0.000	-0.2
HLTH/WLFR/RCN	0.162	0.200	-0.038	-19.0
TOTAL EXPEND.	3.689	3.667	0.022	0.6
TOTAL DEBT	6.019	5.956	0.063	1.0
MILL RATE	0.032	0.034	-0.002	-4.7
GRAND LIST	84.348	80.997	3.350	4.1

REPORTS FOR YEAR 1970

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	3.473	3.552	-0.079	-2.2
STATE	0.955	0.996	-0.041	-4.1
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.251	0.251	0.000	0.0
TOTAL S,F,L	1.206	1.247	-0.041	-3.3
TOTAL REVENUE	4.678	4.799	-0.121	-2.5
EXPENDITURES:				
SCHOOLS	2.686	2.688	-0.002	-0.1
MAINTENANCE	0.275	0.295	-0.020	-6.8
DEBT SERVICE	0.733	0.729	0.004	0.6
NORM. CAPITAL	0.095	0.116	-0.021	-18.2
TOWN ADMIN.	0.360	0.329	0.030	9.2
PUBLIC SAFETY	0.341	0.350	-0.009	-2.6
HLTH/WLFR/RCN	0.189	0.176	0.013	7.4
TOTAL EXPEND.	4.678	4.679	-0.001	-0.0
TOTAL DEBT	8.591	8.625	-0.034	-0.4
MILL RATE	0.041	0.041	0.000	0.4
GRAND LIST	84.354	87.026	-2.672	-3.1

REPORTS FOR YEAR 1971

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	4.087	4.152	-0.065	-1.6
STATE	3.642	3.642	-0.000	-0.0
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.216	0.218	-0.002	-1.0
TOTAL S,F,L	3.858	3.860	-0.002	-0.1
TOTAL REVENUE	7.944	8.012	-0.068	-0.8
EXPENDITURES:				
SCHOOLS	3.254	3.283	-0.029	-0.9
MAINTENANCE	0.299	0.303	-0.004	-1.3
DEBT SERVICE	3.318	3.274	0.044	1.4
NORM. CAPITAL	0.116	0.100	0.015	15.4
TOWN ADMIN.	0.378	0.378	0.000	0.1
PUBLIC SAFETY	0.371	0.363	0.008	2.3
HLTH/WLFR/RCN	0.208	0.212	-0.004	-1.7
TOTAL EXPEND.	7.944	7.913	0.031	0.4
TOTAL DEBT	7.117	6.482	0.635	9.8
MILL RATE	0.044	0.046	-0.002	-3.8
GRAND LIST	92.354	90.665	1.689	1.9

REPORTS FOR YEAR 1972

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	4.895	4.470	0.425	9.5
STATE	1.163	1.607	-0.444	-27.6
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.236	0.236	-0.000	-0.2
TOTAL S,F,L	1.399	1.843	-0.444	-24.1
TOTAL REVENUE	6.294	6.314	-0.020	-0.3
EXPENDITURES:				
SCHOOLS	3.844	3.613	0.232	6.4
MAINTENANCE	0.317	0.292	0.025	8.6
DEBT SERVICE	0.915	0.790	0.126	15.9
NORM. CAPITAL	0.127	0.104	0.023	22.6
TOWN ADMIN.	0.454	0.433	0.021	4.9
PUBLIC SAFETY	0.405	0.433	-0.027	-6.3
HLTH/WLFR/RCN	0.229	0.233	-0.003	-1.5
TOTAL EXPEND.	6.294	5.897	0.397	6.7
TOTAL DEBT	11.053	6.532	4.522	69.2
MILL RATE	0.049	0.046	0.003	5.8
GRAND LIST	100.595	96.117	4.478	4.7

REPORTS FOR YEAR 1973

TOWN BUDGET (IN $MIL)

	SIMULATED
REVENUES:	
PROPERTY TAX	5.699
STATE	1.314
FEDERAL	0.000
LOCAL	0.266
TOTAL S,F,L	1.580
TOTAL REVENUE	7.279
EXPENDITURES:	
SCHOOLS	4.490
MAINTENANCE	0.344
DEBT SERVICE	1.041
NORM. CAPITAL	0.146
TOWN ADMIN.	0.546
PUBLIC SAFETY	0.454
HLTH/WLFR/RCN	0.259
TOTAL EXPEND.	7.279
TOTAL DEBT	12.753
MILL RATE	0.051
GRAND LIST	111.101

REPORTS FOR YEAR 1975

TOWN BUDGET (IN $MIL)

	SIMULATED
REVENUES:	
PROPERTY TAX	7.774
STATE	1.743
FEDERAL	0.000
LOCAL	0.359
TOTAL S,F,L	2.102
TOTAL REVENUE	9.876
EXPENDITURES:	
SCHOOLS	6.244
MAINTENANCE	0.408
DEBT SERVICE	1.345
NORM. CAPITAL	0.188
TOWN ADMIN.	0.755
PUBLIC SAFETY	0.592
HLTH/WLFR/RCN	0.343
TOTAL EXPEND.	9.876
TOTAL DEBT	16.883
MILL RATE	0.056
GRAND LIST	138.478

REPORTS FOR YEAR 1980

TOWN BUDGET (IN $MIL)

	SIMULATED
REVENUES:	
PROPERTY TAX	12.702
STATE	3.289
FEDERAL	0.000
LOCAL	0.709
TOTAL S,F,L	3.998
TOTAL REVENUE	16.700
EXPENDITURES:	
SCHOOLS	11.552
MAINTENANCE	0.509
DEBT SERVICE	1.665
NORM. CAPITAL	0.174
TOWN ADMIN.	1.057
PUBLIC SAFETY	1.099
HLTH/WLFR/RCN	0.644
TOTAL EXPEND.	16.700
TOTAL DEBT	21.061
MILL RATE	0.058
GRAND LIST	220.798

Method of Estimation

Data

An annual time series of both budget items and exogenous determinants was available for the Town of Guilford from 1961 to 1972. The exogenous variables included the cost of living index, school enrollments, and a time series of population and housing measures generated by the SMSA model.

It should be emphasized that, with the exception of the cost of living index, all "exogenous" variables are themselves estimates - either from the New Haven model (households, construction, migration, etc.) or from the school enrollment estimation. They are, however, exogenous to the budget sector.

In contrast, the dependent variables are actual expenditures and revenues for the period as obtained from town reports. They are expressed in either current or constant dollars, depending on whether the inputs were primarily materials or services. The Bureau of Labor Statistics Cost of Living Index (1967 = 1.0) is employed, since we are assuming primarily an effect on salaries. Where the quantities were estimated in current dollar form, an additive specification for cost of living was employed. The reason for the two forms is discussed below under "Cost of Living Adjustment."

Method

The approach taken to estimating the budget is to describe the yearly levels of expenditures, revenues and tax base by a set of linear equations which are then estimated with least squares regression techniques. This approach is justified, since budgets, particularly their recurring parts, are essentially rates times levels of service, and the like. It is here that a model which is linear in the parameters (not necessarily in the variables)[3] may be hypothesized to be most nearly appropriate. While it is true that the rates themselves are not necessarily fixed over time, much of this variability may be accounted for by "inflation" — a cost-of-living adjustment — which can be modeled as a nonlinearity in the variables, preserving the fixed coefficients.

[3] A model such as $Y = a + b \cdot (x*x) + c \cdot \log(w)$ is linear in the parameters, a, b, c, although nonlinear in the variables x and w. One such as $Y = a + e^b \cdot x$, is nonlinear in b and cannot be transformed to be linear in both a and b.

For the most part, very simple structures worked quite well, and there was little simultaneity involved. One equation was used for each line item of expenditure and revenue, one for debt and one for the Grand List of taxable property. Total expenditures and other (nonproperty tax) revenues were simply the sums of the components. Property tax revenue was total expenditures less other revenues. The mill rate was simply the ratio of property tax revenues to the Grand List. Thus total expenditures, other revenues, property tax revenue, and the mill rate were identities.

The output of the New Haven model from 1961-1972 was treated as a most likely estimate of yearly values of the other variables. These yearly estimates then provided 11 observations upon which to base statistical estimation.[4] An important limitation is that only 11 observations provided a severely limited number of "degrees of freedom". Very simple structures were estimated by necessity, although it turned out that they were sufficient in most cases.

The most severe constraint was that our purposes were simulation, and the estimated model might be used far outside the range of the data. Sensitivity analysis was used to avoid this problem. Problems became apparent when, for example the amount of new construction was included as one determinant of a budget line and a simulation involved stopping all construction. In such cases, expenditures sometimes became negative or decreased rapidly because of the way the parameters were fitted. However, due to the strong trends in the series, many alternative formulations fit surprisingly well. When forecast (simulated) under differing assumptions, the essential weaknesses, primarily due to nonbehavioral aspects, came out strongly. In a number of cases, we sacrificed goodness-of-fit for a more believable, and hopefully more robust structure.

[4]We fitted the model on the 1961-1971 observations only.

Our approach ignores economies of scale. However, the expenditures are all essentially recurring costs, with the discontinuous expansion of the physical plant being reflected in debt. Debt is currently poorly modeled, precisely for that reason. However, its effect is felt only indirectly through debt servicing, and this greatly scales down the effect it does have.

Since exogenous variables in some equations were included as dependent variables in other equations, an instrumental variable technique had to be employed in these cases. We used two-stage least squares, a commonly-used limited-information estimator.[5] In the tables which follow, the two-stage estimates were derived by actually performing the estimation in two stages -- first regressing the endogenous variables on the instruments, obtaining the predicted values, then using these in the final estimation -- although the program used had facilities for both.[6]

Criteria for Estimation

The standard techniques of regression analysis were of course available. The corrected R-squared is an estimate of the variance of the dependent variable explained by the equation. While not unbiased, it corrects for the number of degrees of freedom — thus adding more explanatory variables may decrease this estimate. The standard error estimates the standard deviation of the errors of estimation. We have also expressed this relative to the mean of the dependent variable.

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[5] See Henri Theil. Principles of Econometrics, Wiley (New York, 1971), chapters 9 and 10.

[6] Robert Schlaifer. User's Guide to the AQD Collection, Third Edition. Harvard Business School (Boston: 1973).

Two tests were performed on the significance of coefficients. The first is the stardard marginal "t" test for the coefficient being significantly different from zero (a two-tailed test). The second is the so-called Chow test,[7] an F-ratio which tests whether the omission of one or more explanatory variables significantly increases the sum of squared residuals. It is a useful tool, but only appropriate for ordinary least squares. This is so since the F distribution assumes independent Chi-squares in the ratio, and in two-stage least squares the errors are constructed to be nonindependent.

Three other statistics were computed from the errors. One (Sizecor) is the correlation of the absolute value of the errors and the predicted value of the dependent variable. This should be close to zero. The other two are mathematically-equivalent tests of serial correlation of the residuals. The autocorrelation coefficient (Autocor) correlates each error with the preceding one. This should be zero. The Durban-Watson statistic is a measure for testing the zero autocorrelation hypothesis. Its expected value is 2.0 if no autocorrelation is present. Since autocorrelation indicates the omission of important explanatory variables, these are useful measures. These quantities are included with the regression equations.

We have also examined the error relative to the actuals (per cent error). In addition, as we mentioned above, we examined the behavior of the equations under simulation experiments, in order to perform sensitivity testing.

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[7] Gregory C. Chow, "Tests of Equality between Subsets of Coefficients in Two Linear Regressions," Econometrica: 28 (1960), 591-605.

Cost of Living Adjustment

Before we turn to a discussion of each equation, a note on the choice of form in which to use the cost of living index is in order. There are three options. The cost of living could enter additively, the dependent variable could be deflated, or, what is almost equivalent, cost of living could enter multiplicatively on the right-hand side of the equation. A rationale for the heuristics we followed in choosing a specification is as follows:

Deflating the left-hand side or having cost of living enter multiplicatively on the right-hand side is essentially equivalent except that the former assumes a homogeneous model -- one without a constant term. This can be seen easily if the cost of living (c) is assumed nonstochastic.

1) $y = \alpha + \beta\, c\, x + \varepsilon_1$ $\quad (E(\varepsilon_1) = 0;\ \text{Var.}(\varepsilon_1) = \sigma_1^2 I)$
implies

2) $y/c = \frac{\alpha}{c} + \beta x + \varepsilon_1/c$ $\quad (E(\varepsilon_1/c) = 0;\ \text{Var.}(\varepsilon_1/c) = (\sigma_1/c)^2 I)$
whereas

3) $y/c = \alpha + \beta x + \varepsilon_2$ $\quad (E(\varepsilon_2) = 0;\ \text{Var.}(\varepsilon_2) = \sigma_2^2 I)$
implies

4) $y = \alpha c + \beta c x + c\varepsilon_2$ $\quad (E(c\varepsilon_2) = 0;\ \text{Var.}(c\varepsilon_2) = (c\sigma_2)^2 I)$

Equation (2) is different from (3) only in the constant term and the estimated variance of the coefficients. The same is true of (1) and (4). As it turns out in our sample, the average of the cost of living variable is about unity, so the effect is slight, and we employed (3).

Of more importance is the additive assumption.

5) $y = \alpha + \beta c + \gamma \chi + \varepsilon$

is obviously different from (1) or (4), and hence (3) by implication. We chose between the additive form (5) and the deflated form (3) as to whether the line item was a "service" item which varied largely with level of the population served (which was what we had to work with) or whether it varied largely according to materials purchased, etc., which we did not have data on. For service items (such as school current expenditures), we employed the deflated form and for materials-type items (suchaas normal capital expenses) we employed the additive form. In a case such as public safety, which includes both service and materials-type expenditures, the choice between the two forms was mute, and this was relfected in the roughly equal explanatory power of the two forms.

Estimation: Expenditures

School Expenditures

This is the largest item in the town budget, and we will devote more attention to problems of its estimation and forecasting for this reason. In addition, it provides a good example of the approach and its problems.

Since current school expenditures are highly dependent on the costs of servicing enrollments, we employed the "service" specification and predicted school expenditures deflated by the cost of living. In this case, the choice of model was not the problem -- due to an extreme degree of collinearity among the variables almost any model did quite well. As Table 4 reveals, all of the correlations between school expenditures and numbers of children are above .9. The intercorrelations among the independent variables are also quite high.

Table 4

Intercorrelations of School Enrollment Variables with Expenditures - 1961-1971

Enrollments	Enrollments: Kinder-garten	Enrollments: Ele-mentary	Middle School	High School	Total Enroll.	Kindergarten & Elementary	Middle & High
Kindergarten	1.0						
Elementary	.97	1.0					
Middle School	.96	.99+	1.0				
High School	.95	.99	.99+	1.0			
Total Enrollments	.97	.99+	.99+	.99+	1.0		
Kind. & Elem. Enr.	.98	.999+	.99+	.99	.99+	1.0	
Middle & High Enr.	.95	.99+	.999+	.999+	.99+	.99	1.0
Expenditures							
School Exp./ Cost of Living	.95	.98	.98	.99	.98	.98	.98

We will discuss several alternative formulations in this case to illustrate the effect of the collinearity and also how the specification was influenced by the requirements of the simulation.

The results of the estimations are displayed in Table 5.[8] From Table 5 it can be seen that the use of only total school enrollments to predict school expenditures (Estimate 1) yields an R^2 of .96, with a standard error of estimate about 8% of the mean of the dependent variable. However, this form is not sensitive to changes in the mix of the enrollments — a shift from elementary to high school grades would not affect the estimate. This is undesirable for simulation, as well as from a common-sense point of view.

In addition, The Durban-Watson statistic indicates a significant amount of autocorrelation may exist. Although the Durban-Watson statistic falls within the "inconclusive" range, the independent variable is smoothly-varying in the sense that its first and second differences are small compared with the range of variable itself (see Table 6). In such a case it has been shown [9] that the critical region of rejection includes that considered "inconclusive" in published tables. Consequently, we should probably consider the autocorrelation significant -- another indication that the specification is poor.

In Estimate 2 the sum of kindergarten and elementary enrollments is introduced to capture the effect of mix changes. This actually increases the estimated standard error by reducing the degrees of freedom. In addition,

[8] Note on reading the tables: Each equation fitted is listed in one column. The dependent variable and estimate number are listed at the head of the column, coefficients for the independent variables next, then the various statistics.

[9] Henri Theil and A. L. Nagar, "Testing the Independence of Regression Disturbances," Journal of the American Statistical Association: 56 (1961), 793-806.

Table 5

Estimation of School Expenditures
($ million)
1961-1971

Dependent Variable:	School Expenditures/Cost of Living			
Estimate	1	2	3	4 (used)
Independent Variables:				
Constant	-1.045***	-.8453*	-.8399*	.7032
Kindergarten Enrol.				.002583+
Elementary Enrol.				.004341+
Middle Enrol.				-.02089**
High Enrol.				.01320**
Kind. & Elem.		-.001194	-.00035+	
Mid. & High			+.00159+	
Total Enrol.	.001023***	.001573+		
Degrees of Freedom	9	8	7	6
R^2 (corrected)	.960	.957	.957	.987
Standard Error	.1165	.1215	.1210	.06755
S.E./Mean (y)	.075	.079	.078	.044
Size Cor.	.707	.704	.705	-.087
Autoreg.	.045	.337	.352	.198
Durban-Watson	1.300*	1.111*	1.101*	1.413 ?

Significance Levels:

+ $.05 < p < .1$
* $.01 < p < .05$
** $p < .01$
*** $p \approx 0.0$
? Durban-Watson incolclusive at the .05 level

neither enrollment coefficient is significant, by conventional standards, and autocorrelation is still a problem.

Including the sum of the two lower grades and the sum of the two higher grades changes the result little (Estimate 3).

However, by breaking out all four grades separately, we increase the explanatory power, and halve the standard error. This allows for even greater sensitivity to mix changes by grade and produces significant coefficients for the higher grades. While the Durban-Watson statistic is again in the inconclusive range, the changes in kindergarten enrollment are not smooth, and the test cannot reject the zero autocorrelation hypothesis.

This specification, while it fits quite well and is sensitive to mix changes, does not allow for program planning in the conventional sense, nor are changes in productivity or the utilization of facilities accounted for. Judging from the low error in estimating this category in the past, these factors did not seem to show abrupt discontinuity in the 1960's. This is in itself significant. However, it would be desirable to be able to incorporate such considerations.

In summary, it should be noted that, although school expenditures are easy to estimate in a growing town and the grade composition of the school population significantly improves the ability to predict expenditures, from a planning perspective other aspects are important to consider as well. The best use of these estimates is perhaps their use in providing an estimate of the "no change" outcome.

Table 6

Smoothness of the Enrollment Series
1961-1971

Grade	Range of Series	First Range	Difference (2)/(1)	Second Range	Difference (4)/(1)
	(1)	(2)	(3)	(4)	(5)
Kindergarten	70	33	.47	58	.83
Elementary	709	212	.30	290	.34
Middle School	359	67	.19	68	.19
High School	481	98	.20	43	.09
Total Enrollments	1,555	337	.22	384	.25
Kindergarten & Elementary	757	245	.32	348	.45
Middle & High	840	170	.20	88	.10

Health, Welfare, Recreation

This category is composed of a very mixed set of functions, from the Conservation Commission to Social Services and the Department of Health. This is primarily a "service" category, the services being performed for households and people. The dependent variable was thus expenditures deflated by the cost of living.

Measures of demand were total households, and the white and minority populations, 0-19 years of age. In addition, 1964 was an abnormally low year for expenditures, so a dummy variable was introduced for that year. This was done so that the equation would capture the underlying relationship to population served more closely, rather than being biased by an idiosyncratic event.[10]

Estimate 1 did not include this dummy, and its explanatory power is low. The Durban-Watson Statistic is in the inconclusive range, and Table 8 reveals that the 0-19 years of age variables do not vary in a smooth manner, so the hypothesis of zero autocorrelation cannot be rejected.

Estimate 2 of Table 7 reveals that the addition of the dummy variable has a significant effect on the ability to explain expensitures. Since the coefficients for the household and population variables are all insignificantafter this correction, the population 0-19 variables were dropped (Estimate 3). This improves the explanatory power further. While the improvement is not statistically significant, the coefficients are estimated more reliably. This leaves health, recreation, and welfare expenditures determined basically by numbers of total households.

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[10] One could also drop the observation. Both methods cost one degree of freedom, but the dummy variable approach provides (through the coefficient of the dummy) a measure of how far that year deviated from "normal."

Table 7

Estimation of Health, Welfare, and Recreation
1961-1971

Dependent Variable: Health, Welfare, Recreation/Cost of Living

Estimate	1	2	3 (used)
Independent Variables:			
Constant	.1793	-.1063	-.1592**
Total Households	.00033*	.000138	.000090***
Total White: 0-19	-.00033	-.000059	
Total Minority: 0-19	.00122	.00016	
Dummy - 1964		-.08167**	-.08501***
Degrees of Freedom	7	6	8
R^2 (corrected)	.640	.882	.907
Standard Error	.03042	.01740	.01549
S.E./Mean (y)	.29	.16	.14
Sizecor	-.061	.477	.515
Autoreg	-.369	-.201	-.391
Durban-Watson	2.678 ?	2.388 ?	2.769 ?
Chow Tests	$F(1,6) = 6.24$, $P < .05$		$F(2,6) = .56$, $P > .05$

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$0 \approx 0.0$

? Durban-Watson inconclusive at .05 level

Table 8

Smoothness of Household and Population Growth
1961-1971

Variable	Range of Series (1)	First Difference Range (2)	First Difference (2)/(1) (3)	Second Difference Range (4)	Second Difference (4)/(1) (5)
Total Households	1255	71	.06	89	.07
Total Population	4098	1091	.27	1941	.47
Total White: 0-19	1464	678	.46	1211	.83
Total Minority: 0-19	162	122	.75	231	1.43

Public Safety

This category, composed of police, fire, civil defense, dog catcher, and communications services, seems at first glance to be very strongly related to the population served. However, in Guilford, much of the equipment used in these functions comes from current expenditures. It was thus possible that either the deflated or additive specification was appropriate.

In either case, the determinants were hypothesized to be the same as for health, welfare, and recreation — namely total households and white and minority population aged 0-19. In addition, since 1969 was an abnormally low year for public safety expenditures, a dummy variable was added for this year in order to better capture the underlying relations of the variables of interest.

Since there was some uncertainty as to the proper form of the equation, both the additive and deflated forms for the cost of living were estimated, as is displayed in Table 9. As for school expenditures, the R-squareds are extremely high. This has its dangers, for the estimates of the parameters can be unstable.

Table 9

Estimation of Public Safety Expenditures
1961-1971

Dependent Variable:	Public Safety		Public Safety/ Cost of Living	
Estimate	1	2	3 (used)	4
Independent Variables:				
Constant	-.9803***	-.5322***	-.2146**	-.2326***
Total Households	-.000142+	.000075**	.000121*	.000145***
Total White: 0-19	+.000215*		.000012	
Total Minority: 0-19	-.001161*		.000074	
Cost of Living	.9642**	.5168***		
Dummy - 1969	-.1630***	-.1460***	-.1224***	-.1302***
Degrees of Freedom	5	7	6	8
R^2 (corrected)	.998	.995	.987	.986
Standard Error	.003814	.00604	.007002	.007425
S.E./Mean (y)	.018	.030	.035	.037
Sizecor	.171	.782	.619	.213
Autoreg	-.487	-.670	-.041	.168
Durban-Watson	2.815 ?	2.595 ?	1.828 ?	1.500 ?
Chow Tests	$F(2,5) = 3.04$, $P > .05$		$F(2,6) = 1.24$, $P > .05$	

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p \approx 0.0$

Both the additive specification (Estimates 1 and 2) and the deflated specification (Estimates 3 and 4) are evidence of this. For example, when the two population 0-19 variables are included in Estimate 1, total households is significant, whereas when they are excluded (Estimate 2), total households becomes significant. The reason for this can be found in Table 10, which presents the intercorrelations between these variables.

Table 10

Intercorrelations Between Public Safety Determinants

	Cost of Living	Total Households	White 0-19	Minority 0-19	Public Safety	Pub. Safety/ Cost of Living
Cost of Living	1.0					
Total Households	.96	1.0				
White, 0-19	.97	.95	1.0			
Minority, 0-19	.89	.79	.93	1.0		
Public Safety	.87	.85	.92	.91	1.0	
Public Safety/ Cost of Living	.78	.79	.86	.84	.98	1.0

Households and the 0-19 population measures are all highly intercorrelated, thus one is a good substitute for another. The same holds true for the deflated form (Estimates 3 and 4) although to a lesser extent. In neither case does the ommission of the population 0-19 variables reduce the error of estimate significantly.

There is little basis on which to choose an equation since all of the R-squares are high and the Durban-Watson statistics are in the inconclusive range for all equations.[11] Estimate 3 was employed. Although it has one of the lower correlations, this is an advantage in a collinear situation. In addition, autocorrelation seems to be less of a problem, and it is possible to include all of the hypothesized determinants, including cost of living, although the coefficients for population ages 0-19 have large standard errors.

[11]The "smoothness criterion" used above is inapplicable here, since a dummy variable is included in the set of regressors.

The coefficients imply a positive relationship to numbers of households, and lesser contributions from population 0-19.

Maintenance

Maintenance consists partly of activities, such as highway maintenance, which involve servicing households, but with a considerable amount of materials. Other activities, such as maintenance of the Town Hall, have little relation to population served, but do involve salaries and materials. The choice of whether to deflate expenditures by the cost of living (the "service" specification) or whether to have cost of living enter additively as a proxy for the cost of materials and salaries (the "materials" specification) is somewhat moot.

On balance, however, it seemed likely that non-service items might predominate, and the additive "materials" form was employed, although the deflated "service" form was tested.

Total households and the amount of new construction were introduced as a measure of demand for maintenance services. In a larger town, the amount of dispersion of development might also be necessary, but its use does not seem warranted here.

The results of this estimation are displayed in Table 11. Due to the ambiguity in the choice of equation forms, both additive and deflated forms for cost of living are displayed. The additive form with households and construction (Estimate 1) performs best in terms of both the significance of the coefficients and the variance explained. Cost of living and the amount of new construction have an expected positive effect on expenditures, while the partial effect of numbers of households is slightly negative, perhaps indicating economies of scale.

Table 11

Estimation of Maintenance Expenditures
1961-1971

Dependent Variable:	Maintenance Expenditures		Maintenance Exp./ Cost of Living	
Estimate	1	2 (used)	3	4
Independent Variables:				
Constant	-.4084**	-.2594**	.00031	.02684
Total Households	-.00008+	-.000017	.000054**	.000057**
New Construction	.00104*		.00027	
Cost of Living	.7146**	.5133**		
Degree of Freedom	7	8	8	9
R^2 (corrected)	.922	.891	.640	.668
Standard Error	.01430	.01684	.01688	.01620
S.E./Mean (y)	.070	.082	.084	.081
Sizecor	.540	.319	.568	.692
Autoreg	-.514	.015	.079	.080
Durban-Watson	2.862 ?	1.955	1.750	1.761
Chow Tests	F (1,7) = 2.42 P > .05		F (1,8) = .64 P > .05	

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p \simeq 0.0$

There are two problems with this formulation, however. One is that new construction plays an important role, and we intended to experiment with stopping all construction. A second is the amount of autocorrelation. The Durban-Watson statistic is in the "inconclusive" range, but, in contrast with the school expenditure estimation, one of the independent variables (construction) is not smoothly-varying (see Table 12) which indicates that the test is indeed inconclusive.

Table 12

Smoothness of Households and Construction
1961-1971

Variable	Range of Series (1)	First Difference Range (2)	First Difference (2)/(1) (3)	Second Difference Range (4)	Second Difference (4)/(1) (5)
Cost of Living	.316	.075	.24	.029	.09
New Construction	35	24	.69	28	.80

Dropping new construction (Estimate 2) has several effects. For one thing, autocorrelation is not a problem. The standard error rises slightly, although a Chow test indicates that the difference is not significant - i.e., dropping construction does not affect the explanatory power of the equation. Interestingly, the contribution from total households is essentially zero, so we are left with maintenance expenditures being determined by the effect of the cost of living.

Estimates for the deflated form of maintenance expenditures (Estimates 3 and 4) reveal that households have a slight, if positive, and significant, effect on deflated expenditures. The variance explained is much lower, however, and Estimate 2 was used.

Town Administration

This category is a "residual" one, including everything not included in the other expenditure categories. In general it has to do with the day-to-day administration of town functions. Included are the Board of Selectmen, whose expenditures are not directly related to any population, the Planning and Zoning and the Engineering Departments, whose workload is responsive to the growth of the town, and the Town Clerk, whose workload is responsive to turnover of property.

There are clearly numerous possible determinants of administrative expenditures. In and out migration, and the title changes they bring, would affect the Town Clerk. Total construction would affect the Clerk, as well as affecting Planning and Zoning, and Engineering. Total population or households would also affect these departments, as well as the Assessor. Finally, cost of living would enter into all town administration functions.

The choice of additive or deflated form for the cost of living variable was again a problem. It was hypothesized that the deflated, "service", form might be more appropriate, but this proved false. It was also found that total population, rather than total households, performed better as a predictor. Table 13 presents the estimates made subsequent to these findings.

An estimate (Estimate 1) employing migration, cost of living, population and construction had a satisfactory fit, however, many of the coefficients lacked significance.[12] When a dummy variable for 1963, an outlier in the residuals, was introduced, (Estimate 2) the standard errors of the migration variables were reduced, although the dummy variable was not itself significant. Interestingly, when construction, itself insignificant, was dropped, the standard errors of the other coefficients rose (Estimate 3).

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[12] The lack of smoothness for construction (Table 12) and in- and out-migration render the Durban-Watson test inconclusive.

Table 13

Estimation of Town Administration Expenditures
1961-1971

Dependent Variable:	Town Administration Expenditures		
Estimate	1	2	3 (used)
Independent Variables:			
Constant	-1.384	-1.496*	-.8063**
In-migration	.001067	.00181+	.001182
Out-migration	-.003084+	-.00353+	-.001368+
Cost of Living	2.746*	2.740*	1.178
Total Population	-.000116	-.000127+	-.0000251
Dummy - 1963		-.06098	-.05166
Total Construction	.00301	.00354+	
Degrees of Freedom	5	4	5
R^2 (corrected)	.878	.904	.877
Standard Error	.03486	.03102	.0398
S.E./Mean (y)	.16	.14	.16
Sizecor	.052	-.072	.330
Autoreg	-.118	-.421	-.402
Durban-Watson	2.199 ?	2.805 ?	2.803 ?
Chow Tests	$F(1,4) = 1.62$, $P > .05$	$F(1,4) = 1.64$, $P > .05$	

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p < 0.0$

Table 14

Smoothness of Migration Series - Households
1961-1971

Variable	Range of Series (1)	First Difference Range (2)	(2)/(1) (3)	Second Difference Range (4)	(4)/(1) (5)
In-migration	100	352	3.52	348	3.48
Out-migration	105	234	2.23	245	2.33

Estimate 2 was employed initially. This implies a positive role for immigration, cost of living and construction, but a negative role for the partial effects of outmigration and total population. However, in the zero-growth simulation, the lack of construction caused the estimate to become negative initially. Estimate 3 was then employed with satisfactory results.

Normal Capital

Normal capital, consisting of capital outlay, library expansion and reserve fund categories is obviously not a "service" category, although population served does enter into library expansion. Thus, an additive specification for cost of living and numbers of households was employed (Estimate 1). In addition, dummy variables were used in 1967 and 1969 to correct for unusual outlays (Estimate 2). Although the R^2 was moderately high, the errors were somewhat large on a percentage basis. However, they were small relative to the overall budget. Table 15 details these results, and an example of the "deflated" specification (Estimate 3), which was unsuccessful. The degree of autocorrelation of the errors is moderate, but not significant statistically for Estimates 2 and 3.

Debt Service

Debt Service is very easy to estimate, and is discussed here since it is an expenditure category. The approach was first to estimate an inflation-adjusted

Table 15

<u>Estimation of Normal Capital</u>
1961-1971

Dependent Variable:	Normal Capital		Normal Capital/ Cost of Living
Estimate	1	2 (used)	3
Independent Variables:			
Constant	-.2023*	-.2557***	-.05124
Total Households	-.000104+	-.00011**	.000034*
Cost of Living	.5664*	.6415**	
Dummy - 1967		.02658*	.009204
Dummy - 1969		-.06607**	-.06090*
Degrees of Freedom	8	6	7
R^2 (corrected)	.379	.871	.361
Standard Error	.02609	.01186	.02179
S.E./Mean (y)	.51	.23	.44
Sizecor	.245	.699	.202
Autoreg	-.402	-.690	.425
Durban-Watson	2.804?	2.696?	.977
Chow Tests		$F(2,6) = 5.80$ $p < .05$	$F(1,6) = 3.43$ $p > .05$

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p \approx 0.0$

interest rate as a function of debt, with a correction for 1971, when a large lump-sum payment was made. These results are presented in Table 16. If one proceeds as in Estimate 1, a biased estimate of the interest rate results, since total debt is in the same system. To eliminate this an instrumental variable for debt was constructed (Estimate 2a), then debt service was regressed on this instrument (Estimate 2b). Debt service was estimated in current-dollar form, since total debt was also in this form, so the dummy for 1971 was multiplied by the cost of living. In the model, Estimate 2a was used for Total Debt, although the specification was arrived at in Table 19.

Estimation:Revenues

State Revenues

State revenues aid highway and building construction and both the recurring and capital costs of education. The deflated revenues were first estimated as a function of school expenditures, total households, as a proxy for road and building activity, and a dummy for 1971, when a large supplemental revenue grant was received (see Table 17).

Since school expenditures were endogenous to this sector, an instrumental variable technique was required here as well. First, it was necessary to choose a set of instruments on which to regress school expenditures, compute the estimated values (Estimate 1), then use this constructed variable in place of school expenditures (Estimate 2), thus disposing of the estimate of the error term (and the presumed correlated error). We employed the exogenous variables from the school expenditure and revenue equations.

The method was successful, in that it revealed an insignificant coefficient for the "purged" school expenditures, and the importance of total households. Dropping the school expenditure variable (Estimate 3) did not seem to

Table 16

Estimation of Debt Service
1961-1972

Method:	Ordinary Least Squares	Two-Stage Least Squares	
Dependent Variable:	Debt Service/ Cost of Living	Total Debt	Debt Service
Estimate:	1	2a	2b
Independent Variables:			
Constant	.1166***	-31.81+	-.1826
Total Debt/ Cost of Living	.06913***		
Dummy - 1971	2.213***		
Cost of Living		46.08+	.3286+
Dummy 1971* Cost of Living		-2.989*	2.191***
Middle High School Enroll.		-.01258+	
Total Enroll.		.004176	
Total Households		-.001935	
Dummy - 1968		-1.289*	
Dependent Regressor:			
Total Debt			.06161***
Degrees of Freedom	8	4	7
R^2 (corrected)	.999	.983	1.000
Standard Error	.01949	.2956	.01636
S.E./Mean (y)	.034		
Sizecor	-.419	-.480	
Autoreg	.157	-.563	
Durban-Watson	1.634	3.068	Not Applicable

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p \leq 0.00$
?	Durban-Watson not conclusive at .05 level

Table 17

Estimation of State Revenues
1961-1971

Method:	Two-Stage Least Squares		Ordinary Least Squares
Dependent Variable:	School Exp./ Cost of Living	State Revenues/ Cost of Living	State Revenues/ Cost of Living
Estimate	1a	1b	2 (used)
Independent Variables:			
Constant	-1.084^{+}	$-.5499^{+}$	-.8340***
Kind. Enroll.	.006495		
Elem. Enroll.	-.000988		
Middle Enroll.	.007873		
High Enroll.	-.001355		
Total Households	-.000526	.0003051*	.0004621***
Dummy 1971	.4733*	2.079***	2.134***
Dependent Fegressor:			
School Exp./ Cost of Living		.1290	
Degrees of Freedom	4	7	8
R^2 (corrected)	.998	.998	.998
Standard Error	.02805	.03362	.03372
S.E./Mean (y)	.018	.044	.044
Sizecor	-.559	-.660	-.377
Autoreg	-.413	-.456	-.477
Durban-Watson	2.713	Not Applicable	2.998?

Residual Cross-Correlation = .246

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p \approx 0.00$

reduce the standard error significantly,[13] but it did reduce the value of the errors with the level of the dependent variable, and Estimate 3 was employed.

Local Revenues

Local revenues came largely from local departmental fees, Board of Education revenues, and interest on short-term bonds. We specified its deflated value to be a function of total enrollments (for tuition), construction (building permits), total population (user charges), inmigration (recording fees), and dummies for the years 1963 and 1970 when there were special receipts. The results are detailed in Table 18. Estimate 1, which includes all of these factors, is not particularly good, but by dropping all but total population and the 1970 dummy (Estimate 2), a more satisfactory estimate is obtained, although, again, the reduction in variance is not significant.

Property Tax

The property tax item is an identity -- expenditures less State and Local Revenues. Thus, the budget is always balanced, the the Property Tax takes up the slack.

[13]An F test is inappropriate here, since this is two-stage least squares.

Table 18

Estimation of Local Revenue
1961-1971

Dependent Variable:	Local Revenue/Cost of Living	
Estimate	1	2 (used)
Independent Variables:		
Constant	-.1049	-.2527***
Total Construction	-.000076	
In-migration	-.00036	
Total Population	.00021	.000035***
Total Enrollments	.000054	
Dummy - 1963	.003593	
Dummy - 1970	.04057	.0438*
Degrees of Freedom	4	8
R^2 (corrected)	.828	.899
Standard Error	.02382	.01823
S.E./Mean (y)	.24	.18
Sizecor	-.118	-.377
Autoreg	-.428	-.302
Durban-Watson	2.768 ?	2.555 ?

Chow Test $F(4,4) = .53$
$P > .05$

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p \approx 0.00$

Estimation:Other Categories

Debt

Debt has been largely for schools in the past decade in Guilford. In the future, advanced land acquisition and sewers will take an increasing share. Debt does not enter directly into the Town's expenditures except through Debt Service, so its importance is limited for our purposes. As a result, it is handled simply as a function of cost of living, total and upper-grade enrollments, total households, and a dummy for 1968, an abnormal year.

The estimates are displayed in Table 19. Dropping cost of living, which is nonsignificant, does not significantly reduce the variance, but the full form (Estimate 1) was retained. Of course, this averages through theshold effects, varying classroom sizes, etc. A more flexible approach for planning would be nonstatistical in nature, based on known factors, but we have not implemented this as yet.

Grand List

The Grand List of taxable property is composed of numerous categories, the most important of which are dwelling units, commercial and industrial property, building lots and farm land. The deflated values of the Grand List were modeled as a function of total occupied units, numbers of owner-occupied high-value units (to capture mix changes), and total employment, as a proxy for commercial and industrial property. This is displayed in Estimate 1 of Table 20. Due to collinearity, the standard errors of the occupied units and total jobs variables are high. Dropping the High/Owned variable improved the standard errors of the others but did not significantly reduce the overall error. Even so, Estimate 1 was employed to capture mix changes.

This specification does not enclude a term for the assessment ratio, which limits its usefulness. It was possible to estimate the Grand List successfully because the change in the assessment ratio was gradual, and occurred each year. When revaluation occurs, however, the results of this equation will be considerably in error. Again, a "no change" case is being estimated.

Mill Rate

The Mill Rate was also an identity, being simply the ratio of Property Tax Revenues to the Grand List.

Table 19

Estimation of Total Debt
1961-1971

Dependent Variable:	Total Debt	
Estimate	1 (used)	2
Independent Variables:		
Constant	9.267	5.155+
Cost of Living	-5.973	-
Mid. & High School	-.01359+	-.01571*
Total Enrolled	.02102**	.02032**
Total Households	.01209**	-.01114**
Dummy - 1968	-1.376*	-1.243*
Degrees of Freedom	5	6
R^2	.969	.971
Standard Error	.3943	.3807
S.E./Mean (y)	.11	.11
Sizecor	-.179	.129
Autoreg	-.671	-.621
Durban-Watson	3.278 ?	2.921 ?
Chow Test	$F(1,5) = .79$ $P > .05$	

Significance Levsls:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
	p 0.00

Table 20

Estimation of Grand List
1961-1971

Dependent Variable:	Grand List/Cost of Living	
Estimate	1 (used)	2
Independent Variables:		
Constant	16.03	-12.74
Occupied Units-High/Owned	.02103	
Occupied Units-Total	.003719	.01915**
Total Jobs	.006903+	.005850*
Degrees of Freedom	7	8
R^2 (corrected)	.874	.888
Standard Error	4.271	4.027
S.E./Mean (y)	.069	.063
Sizecor	-.094	-.152
Autoreg	-.020	-.016
Durban-Watson	2.002	1.976
Chow Test	F (1;7) = .54 P $>$ .05	

Significance Levels:

+	$.05 < p < .1$
*	$.01 < p < .05$
**	$p < .01$
***	$p \approx 0.0$

Comparison with an Extrapolation Technique

How much better (or worse) can one do with this technique than with a simple extrapolation? For example, suppose that budgets are thought to increase by a fixed increment each year. Then some model of compound growth would be appropriate. A comparison of the results for 1972 for two of these possible models with the approach presented above is given in Table 21. Additionally, a comparison of the 1977 budget is given.

Two extrapolations are performed. One predicts the 1972 budget line as the 1971 value times the 10-year compound rate. This is more accurate for the school, normal capital and town administration categories, and overall, due primarily to the improved school forecasting. The sum of the line items is far more accurate than the extrapolated total, since an abnormality in debt servicing was corrected in the estimation of this category, but not in the total.

The other extrapolation uses the 1961-68 rate of change to predict the 1968-72 change. This is far less satisfactory than the regression method for all categories except public safety. It is, however, somewhat more representative of the accuracy one might expect from a compound-growth technique, since most forecasts are for greater than one year ahead. Thus, the first extrapolation, while more accurate, may be less realistic as to the actual use of the technique.

Interestingly, the 1972-77 extrapolation utilizing the 1967-72 rate of change was higher for most items than the regression method,

Table 21

Comparison of Results for Various Methods: 1972 and 1977

($ in millions)

Expenditure Category	1972				1977	
	Actual	Regression Model	1971–1972 (10-year rate)*	1968–1972 (7-year rate)**	Regression Model	1972–1977 (5-year rate)***
Schools	$3.613	$3.844 (6.4%)	$3.783 (4.7%)	$3.345 (-7.4%)	$8.012	$8.293
Maintenance	.292	.317 (8.6%)	.324 (11.0%)	.250 (-14.4%)	.450	.468
Debt Service	.790	.915 (15.9%)	.931# (17.8%)	.495 (-37.3%)	1.510	1.920
Normal Capital	.104	.127 (22.6%)	.107 (2.9%)	.049 (-52.9%)	.193	.164
Town Administration	.433	.454 (4.9%)	.420 (-3.0%)	.376 (-13.2%)	.894	.915
Public Safety	.433	.405 (-6.3%)	.407 (-6.0%)	.444 (2.5%)	.757	.848
Health, Welfare, Recreation	.233	.229 (-1.5%)	.242 (3.9%)	.213 (-8.6%)	.441	.512
Summed Total	5.897	6.294 (6.7%)	6.214 (5.4%)	5.172 (-12.3%)	12.257	13.120
Extrapolated Total			9.316 (58.0%)	5.036 (-14.6%)		12.985

*Budget (1972) = Budget (1971) * [Budget (1971)/Budget (1961)]$^{1/10}$
**Budget (1972) = Budget (1968) * [Budget (1968)/Budget (1961)]$^{5/7}$
***Budget (1977) = Budget (1972) * [Budget (1972)/Budget (1967)]
#Debt Service (1972) = Debt Service (1970) * [Debt Service (1970)/Debt Service (1961)]$^{2/10}$ because 1971 an abnormal year.

Note: The percentage error is in parenthesis.

but the two are different by only 3-12 percent for most items.

A very pertinent question then intrudes: if, by employing the compound growth model with slide rule, pocket calculator, or pencil and paper and a few moments' time, one can achieve comparable, or at least acceptable, levels of accuracy as achieved with the regression approach described above, why use the regression approach at all?

There are three possible answers. In the first place, not all lines were predicted equally well by the compound rate approach. Those which we termed "population-serving" items were well fitted, while the others were less well predicted. Since population-serving items constitute the bulk of the budget, the total budget is well predicted, but individual items are not. Which approach is to be favored thus depends upon one's purposes. Estimates of only totals does not require more than compound growth rates, apparently, while interest in component items--finer levels of disaggregation--requires a more flexible approach.

Secondly, while trends are predicted well by a continuation of the trends, this is in part simply an algebraic way of begging the question. For all series, the method can be made to fit at least two historical points perfectly, and for smoothly-varying series, it will be close to many others. In contrast, all that is guaranteed for a linear regression with constant term is that it pass through the mean value of all variables. A close fit with even a smoothly-varying series is not guaranteed by the technique unless appropriate exogenous variables are chosen. While a close fit does not indicate that "causes" have been pinpointed, one can at least say that a fortuitous coupling of one variable with others has been achieved.

This leads directly to a third point. A trend extrapolation, of no matter what degree or form, can still travel only one path. The possibility of varying the inputs to observe changes in the outputs--i.e., of simulation--is precluded, since the only input is time. Below is reported an experiment in which growth in the town was stopped for ten years and the effects observed. This would be impossible to do with a trend extrapolation, unless a change in a trend were related proportionally (say) to a change in population, households, etc. But this is precisely what a regression equation does. Then, the only difference would be the choice of criterion function--regression methods typically use least squares, but other choices can be made. As was remarked in Chapter 4, this is a difference in execution, but not in intent. Parameter values may vary under different fitting operations, but this is not sufficient to justify considering them different "approaches".

One could, of course, abandon fitting constants of proportionality altogether and simply assert their values. However, unless otherwise impossible, the values of parameters (if nothing else) should be the objects of, rather than the assumptions of research.

The argument would thus appear to be somewhat circular. If one wishes to extrapolate trends, then trend extrapolation is sufficient. One must be assured that the trends are constant to use this approach, however. If not, or if one wishes to test cases where they are not, then some more elaborate approach is called for. Although simple, the regression approach followed above is somewhat more elaborate, and is at least a step in the right direction.

The Role of the SMSA Model

The SMSA model was important to the budget module in two respects. First of all, it provided yearly time series for most of the variables used in estimating the equations. Secondly, it provided a means of "experimenting" on the town and producing future time series which were consistent with the dynamics of the region as a whole.

Important determinants of the line items of the budget were found to be numbers of households, total population and children by race, enrollments by grade, new construction (although not used for reasons discussed above), in and out-migration of the population, numbers of occupied units by type, employment, and cost of living. Cost of living was extrapolated, but all the rest were taken directly from the output of the SMSA model or, in the case of school enrollment, estimated based on the disaggregated inputs from the SMSA model. The SMSA model thus provided the yearly time series which were required to supply the exogenous variables for the estimation.

The question as to whether there would be a simpler way to obtain the inputs for the budget estimation then arises. The answer is essentially the same as that given in the last section to the question of extrapolating the budget items themselves versus using the approach developed here. Translated into the present context, the arguments would be that: 1) successful interpolation (1960-70) or extrapolation of yearly values of the variables depends upon smoothly-varying series, and 2) the possibilities of simulation or experimentation, particularly in a manner consistent with regional dynamics, is precluded.

The evidence presented in Tables 6, 8, 12, and 14 of this chapter indicates that, of the exogenous variables employed, numbers of children 0-19, kindergarten enrollments, new construction, and in- and out-migration of households are not smoothly varying for the period 1961-1971. These estimates are from the SMSA model, of course, and are not actuals. However, the point is that the quantities are, by and large, unobtainable.

For those which are not smoothly-varying, trend projections of a simple variety are wholly unsatisfactory.

The SMSA model, moreover, seems to be fairly accurate in representing the growth of the town. Data are available for the amount of construction from the file of certificates of occupancy of the town. Since these represent habitable units, they are the best measure of construction available. As can be seen, the estimated construction agrees quite closely with that actually tabulated from the file, for the years for which data were collected. It should be noted that the series is not smooth for the historical period, so the results do not simply represent the capturing of a trend. Nor were these actuals used in calibrating the model. Further, the model does not simply continue this trend into the future. Another jump in the construction rate in the late 1970's is forecast as other buildable land in the SMSA is used up.

Table 22

Comparison of Forecast versus Actual Construction:
Guilford, Connecticut

Model Year*	Certificates of Occupancy**	Model Estimates
1972	138	144
1973	173	173
1974	171***	181

Notes:

* The model year runs from 1 April the previous year to 31 March, e.g., "1972" is 1 April, 1971 to 31 March, 1972.

** Taken from a file of actual certificates, late 1970 to late 1974.

*** Estimated from data to 10/74. 101 certificates 4/73-10/74 assumed to represent .59 of year, as in 1973 model year.

Two Simulations

The other advantage of the approach taken in this chapter is the possibility of simulation under varying assumptions.

Two simulations were performed to 1980 to demonstrate the possible uses of the model. One was the base-case run, mentioned above, while a second stopped all construction in Guilford (but not the region) from 1971-1980. Table 22 summarizes the results. The listing of the output for the two runs is presented in Appendix A.

A summary of the results is as follows:

1. The number of occupied units rises only about 6 percent in the zero growth run versus the base run's growth of 67 percent. Over half is from construction in 1970, the rest from a reduced vacancy rate. The basic construction rate was between 3-6 percent for the basic run.

2. The own/rent ratio is about the same for both runs. The percent of high value units rises much more rapidly for the basic (42-55 percent) than the zero-growth (42-48 percent) run.

3. In the basic run, the percentages of young households increases 4 percent, and middle and old aged decreases about 2 percent each. In the zero-growth run, the percent of young households decreases 8 percent, and percent of middle aged and old households increases 3-4 percent each.

4. Percent minority increased 1 percent in the basic run, but remained the same in the zero-growth run.

Table 23

Comparison of Baseline and Zero-Growth Simulations: 1970-1980

Year	1970 Actual	1980 Baseline	1980 Zero-Growth
Households			
Number	3582	5993	3806
Change: 1970-80		+67%	+6%
In Owned Units	81.9%	83.7%	80.9%
In High-Value Units	41.5%	55.2%	48.0%
Age of Head			
20-39	36.0%	40.2%	28.5%
40-64	47.6%	45.9%	52.1%
65+	16.4%	13.8%	19.4%
Minority Heads	7.1%	8.4%	7.4%
Children in Guilford 5-19			
Total	3835	5712	3448
Percent of Total	78.5%	77.9%	82.6%
Public School Enrollments			
Total: K-12	3374	5420	3209
Percent of Children 5-19	88%	94.9%	93.1%
Enrollment/Household	.94	.90	.84
Distribution by Grade			
Kindergarten	8.0%	7.5%	6.1%
Elementary (1-5)	44.9%	38.9%	36.1%
Middle (6-8)	23.7%	23.0%	23.4%
High (9-12)	23.5%	30.6%	34.4%
Town Budget			
Expenditures	$4.679 mil.	$16.700 mil.	$13.633 mil.
School Budget	57.4%	69.2%	64.1%
Grand List			
Value*	$87.0 mil.	$220.8 mil.	$148.9 mil.
Change 1970-80		+154%	+71%
Mill Rate	.041	.058	.079

* Current trends in valuation assumed.

5. Although the number of children 5-19 falls 10 percent from 1970-1980 in the zero-growth run, they make up a larger share of the total number of children in the town. The number enrolled drops only 5 percent, due to this shifting age mix and rising enrollment rates. Although the number of children enrolled per household falls for both runs, the drop is greater for the zero-growth run, due to the older mix of household heads.

6. The enrollment mix shifts to older children. High-school enrollment rises 24-30 percent for the basic run and 24-34 percent for the zero-growth run. Again, this is due in part to the older mix of household heads, but also due to the trend toward an older mix of children, generally.

7. Although expenditures are less in 1980 for the zero-growth case than for the basic case, and school costs make up a lesser share of the budget, the mill rate is higher. This is so because the Grand List does not increase at the same rate as expenditures.

Summary

The equations for the budget portion of the model are summarized in Chart 2. Each line item of the budget can be described fairly well by relatively simple linear equations which include essentially "demand" variables as predictors. This conclusion holds true if the description is measured in terms of traditional statistical measures, or in terms of the percent error of estimation. These results lend considerable credence to the view that, at least for a rapidly-growing suburban town, an "external determinants" model is an appropriate description of the budgeting process.

Further, since each equation was fairly successfully estimated, each with different determinants, the divisions employed in the definition of line items seems to be useful. The rationale employed for the inclusion of the cost of living deflator seemed to be borne out by the poorer results obtained when an alternative form was employed in specific instances.

Specific results of the estimation are as follows:

- A disaggregation of the determinants of school expenditures is important, as children in the higher grades are more expensive to educate. This is particularly important when, as now, there is a shift of children to the older age groups.

- Total households or total population enter into all other expenditure items except debt service.

- Where other variables were important, the population served defined the significant determinants. Examples of this are migration and construction for town administration and school population for total debt.

- Determinants of revenues were essentially households and population.

- Determinants of the grand list were, as expected, measures of property holdings, but these measures were aggregate numbers of housing units and jobs.

- Although not statistically fitted, the property tax yield, total expenditures and revenues, and tax rate were estimated well.

Due to the simple construction of the system, and the overwhelming importance of a few variables such as total households, housing units, jobs, school children, etc., it would seem that a short-term or medium-term forecasting and planning tool could be constructed which used only the already-observable aggregates.

Finally, since a model of the SMSA was employed in generating the inputs for the budget equations, it was possible to vary these external inputs in a way consistent with SMSA dynamics. An example of stopping growth in the town from 1971 to 1980 was given. Although expenditures were less in 1980 under no-growth than growth, the Grand List grew even less, and the mill rate was actually higher under the no-growth assumption.

The possibility for such experimentation would seem to be a strong argument in prompting the use of such a model.

Chart 2

Budget Equations

Expenditures

School/COL = $C_0 + C_1$(Kind.Enrol.) + C_2(Elem.Enrol.) + C_3(Mid.Sch.) + C_4(High Sch.)

Health-Welfare-Recreation/COL = $C_0 + C_1$ (Total Households) + C_2 (Year 1964)

Public Safety/COL = $C_0 + C_1$ (Total Households) + C_2 (Total White: 0-19) + C_3 (Total Minority: 0-19) + C_4 (Year 1969)

Maintenance = $C_0 + C_1$ (Total Households) + C_2 (COL)

Town Administration = $C_0 + C_1$ (Immigration) + C_2 (Outmigration) + C_3 (COL) + C_4 (Total Population) + C_5 (New Construction) + C_6 (Year 1963)

Normal Capital = $C_0 + C_1$ (Total Households) + C_2 (COL) + C_3 (Year 1967) + C_4 (Year 1969)

Debt Service = $C_0 + C_1$ (Total Debt) + C_3 (Year 1971 * COL) + C_4 (COL)

Revenue

State Revenue = $C_0 + C_1$ (Total Households) + C_2 (Year 1971)

Local Revenue = $C_0 + C_1$ (Total Population) + C_2 (Year 1970)

Other

Total Debt = $C_0 + C_1$ (COL) + C_2 (Middle + High Enrollment) + C_3 (Total Households) + C_4 (Year 1968) + C_5 (Total Enrollments)

Grand List = $C_0 + C_1$ (Occupied Units - High Value/Owned) + C_2 (Occupied Units - Total) + C_3 (Total Jobs)

Identities

Total Expenditures = School + Health + Public Safety + Maintenance + Administration + Normal Capital + Debt Service

Property Tax Revenue = Total Expenditures - State Revenue - Local Revenue

$$\text{Mill Rate} = \frac{\text{Property Tax Revenues}}{\text{Grand List}}$$

Note: COL = Cost of Living
C_i = are coefficients, $i = 1 \ldots m$
C_0 = is constant term

Chapter 7

Summary and Conclusions

In broad outline, this study has pursued the following argument.

For a suburban town, growth seems in large measure uncontrollable. Few of the forces which have spurred suburbanization are in any way controllable at the local level. Rural to urban migration and changing transportation technology have had their day, but have left their mark and set in motion forces which may take an extended period to work themselves out. In contrast, the phenomena of concentration of blacks and the poor in central cities, with the fiscal imbalances and social tensions they create are far from being played out. And the Federal government, through tax shelters and other subsidies to home ownership, allocates as much or more to aid suburbanization indirectly as it does to ameliorate community problems with direct aid. The institutional changes which might reverse these trends seem far off indeed.

Communities do have a variety of tools -- such as exclusionary zoning and subdivision regulations -- which can be employed to slow growth. However, their use in an overtly exclusionary manner is increasingly being challanged. Apart from this, it would not seem that they could be successfully applied in all localities simultaneously -- suburban growth may be successfully redirected from some localities only if all are not actively pursuing the same strategy

With so many of the determinants of suburban growth outside local control, a community can proceed on an ad hoc basis, hoping the trends remain stable. Alternatively, it can attempt to improve its forecasting ability, in order to better anticipate trends, or its program budgeting ability, in order to more efficiently utilize the resources which it commands.

We have concentrated on the development of a forecasting tool, since the forecasting function should logically precede the program budgeting function. In addition, the importance of external economic, demographic, and social forces in determining the costs of providing town services would seem to make this a relatively more soluble problem. In the case of a growing suburban town, this would seem to be the case. However, the modeling strategy and priorities for problems to be solved might dictate a different approach for a central city.

Desirable features for a forecasting tool include: an adequate representation of the interface with the metropolitan area; a fine level of disaggregation of demand factors, such as types of households, ages of children, and types of dwelling units; representation of the time lags of the determinants; the inclusion of relevant cost considerations, such as capital vs. recurring costs, the lumpiness of investment and economies of scale, consideration of marginal vs. average costs, and the balance between expenditures and revenues.

An overall sketch of the study in terms of the above typology would be as follows:

The system/subsystem interface is handled by the use of a comprehensive model of the SMSA.

Households are characterized by three categories of age, ethnicity and education, and differences in family size and enrollment characteristics found. Children are estimated by age grouping, and demand for school services estimated on this basis. Price and tenure characteristics of units are accounted for and crossed with household type. Density is not treated per se. Time lags associated with immigrants are treated, but existing knowledge limits the adequacy of the model. The town is not large enough to make locational considerations mandatory, although this might be a desirable extension at some future time.

Only public costs are treated. Externalities are not estimated. Both capital and recurring expenditures are accounted for. The importance of existing facilities and the lumpiness of investment are handled implicitly. Appropriation lags are not considered.

Both expenditures and revenues are treated; the local tax base and rate is estimated.

Since computer simulation is relied upon, a discussion of issues surrounding its use precedes the description of the algorithms. It is noted that propositions about phenomena linked by computer logic constitute theory of a flexible variety, and permit extensive disaggregation of actors into types. Also discussed is the partitioning of the problem into SMSA and town models which communicate across the town boundary.

In the discussion of the determinants of school enrollments, the determinants of the number and age distribution of children are treated at length. A large amount of variation was found among classes of household head, dwelling unit types, and migration status. Among the most significant are the large differentials in numbers of school-aged children between owner and renter households, and the varying age distribution of children by migration status. Systematic variation was also found in enrollment rates of children by type of household. Of more importance, however, is the trend for these rates to increase over time. How these and a variety of other influences were integrated into an estimation algorithm is also discussed.

The town budget was described as a system of econometrically-estimated equations. Perhaps the most important finding was the dependence of the budget on cost of living and demands for service in each year, and in particular, the importance of numbers of households as a determinant.

Evaluation and Directions for Further Investigation

The principal areas in which it is worth evaluating the study are: the value of modeling SMSA-local interactions, the value of disaggregation, and the merits and demerits of the particular representations chosen for the enrollment and town budget estimation.

SMSA-Local Interaction

One point emphasised by all the findings of the study is that the use of a set of partitioned models -- in this case the SMSA and the local municipality models -- is not only a desirable modeling strategy but a necessary one as well. Without this, it would have been impossible to account systematically and realistically for the interaction of town and region. The importance of sheer numbers of households in the determination of the town budget was apparant. Standing behind this was the determination of enrollments. Prediction of enrollments in rapidly-growing areas has been traditionally difficult because, typically, the mix of households is changing with the infusion of migrants with new characteristics. Unless SMSA/local interactions are accounted for, this can easily be missed.

The other reason it is valuable to represent the metropolitan-local interface is the possibility it provides for experimentation with town policy within a medium which will maintain the regional accounting in a consistent manner. One example, that of stopping growth in the town, revealed a change in the composition of the population in the town. This was so because of large flows of in and out-migrants -- which in this case were balanced -- working to change the composition of a town which suddenly "looked" quite different to the region as a whole. Without the SMSA model, such experimentation would have been impossible.

Disaggregation

The changing mix of the population is one example of the value of disaggregation in these problems. "No growth" does not mean "no change," but highly aggregated models will make the two appear equivalent. Not only that, but the very estimation of such aggregative models relies on a stability of the mix, or at least a slowly-varying change in the mix. Thus, disaggregation is important at both ends of a model -- in the estimation phase and in the prediction phase.

Chapter 5, in particular, revealed the large variation there is in the numbers and age distribution of children, and how it can change over time. Characteristics of the household head, type of unit, and year moved in all contributed importantly to differences in these rates. A model which ignores such compositional effects must rely on smooth trends or suffer from the presence of changes.

This study illustrated the desirability of disaggregation, but did not prove that the basis chosen was the optimal, or even a necessary one, although the differences seem to be pronounced in many cases. A thorough application of clustering and variance-analysis techniques, on the one hand, and theoretical development, on the other, would seem to be a desirable next step.

Enrollment Estimation

On the positive side, the school enrollment algorithm attempts to deal systematically, and in an extreme amount of detail, with the major components of the process. The procedure explicitly accounts for in and out-migration of households, variations in family size and age mix accross household and dwelling unit types, and through time. The public school enrollment process is handled in a similar manner. One can vary the assumptions and observe the effects -- if fact, much of the present structure was arrived at in this manner.

The model has had practical application in the town where it was developed, and has had an impact on the decision-making process. Of the techniques in use, it is the only one which can simulate a temporary downturn in housing starts, for example, without extrapolating this temporary pause indefinitely into the future.

Conversely, the model development process has revealed large gaps in our knowledge which it was not feasible to fill. While behavioral rationales lie behind all of the operations which take place, in several cases they are not explicitely represented in an intellectually-satisfying manner. Examples are the age-mix and family size adjustments, and, to a lesser extent, the representation of the enrollment process.

Perhaps the weakest part of the procedure was the specification of an algorithm for outmigration of households from the town. Analogies drawn from studies dealing with intercounty movement seemed to be misleading at best. Much more work is required to understand this phenomenon, because of both the difference in demand for services by migration status and the apparent lagged nature of this demand. It would further seem desirable to simplify the representation of the probability of outmigration, so as not to have to account for each annual cohort separately. Very likely this whole procedure could be represented as a Poisson process, which would simplify both modeling and parameter estimation.

Finally, a more extensive set of towns should be studied in order to establish what is unique and what is generalizable about this aspect of the study. While much of the data was regional or national in scope, it seems entirely possible to develop a scheme to allow a calibration of other towns from observable parameters.

Budget Estimation

One important finding is that of the efficacy of the externally-determined budget concept for suburban town budgeting. This effects a great simplification into modeling and estimation, and allows the construction of simple forecasting and planning tools with greater confidence than before. The dominant nature of sheer counts of households or people for forecasting budget-line items was surprising, particularly since, apart from the cost of living, it was not accompanied by measures of purchasing power or tastes, which are usually thought to be important.

Again, the procedure works, and seems to provide at least an estimate of the "expected" budget in the absence of structural change. One can vary the inputs and see what changes might be expected to occur. In particular, the results of one such "no-growth" experiment indicated that stopping growth would prompt an increase in the tax rate over the "normal growth" situation.

Weaknesses of the procedure include the lack of a capability to vary assumptions about productivity or resource utilization, in order to foster planning of this sort. Another is the inadequate handling of capital investment and debt aspects of town growth. This is where actual planning can take place, whether growth continues or is stopped.

The application of capital budgeting methods is sorely needed. Local municipalities make decisions which for them are large, often under great uncertainty. Formal methods such as dynamic programming,[1] or even traditional linear programming methods could be of great benefit. An example of such a decision is currently taking place in Guilford. A long-planned-for expansion of the high school is now being seriously called into question on the basis of greatly-slowed growth during the recent collapse of the housing market. The mental models of many citizens project this downturn, in combination with national declines in fertility, into idle classrooms. In addition, valid questions about the costs or benefits of delay, the possibility of more efficient use of existing classrooms, and others of a similar nature are being voiced. The appropriate decision in the face of the present uncertainty is by no means clear. A procedure which can produce estimates of future conditions under various assumptions, account for all or many items of cost and benefit, and weigh the odds of various outcomes under the various assumptions would be a valuable tool indeed.

Finally, a wider sample of towns should be studied for the same reasons it should be done for the school enrollment estimation. Those aspects of the procedure which are indeed general should be isolated. It is fairly clear, however, that in the case of a severely-constrained budget, the method would have to be augmented. If statistical methods were to be used, full-information methods such as three-stage least squares, would be required. Particularly for the capital investment problem, however, more flexible aspects of simulation would no doubt be of value.

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[1] Colin A. Gannon, "Optimal Intertemporal Supply of a Public Facility Under Uncertainty: A Dynamic Programming Approach to the Problem of Planning Open Space," Regional and Urban Economics: 4(1974), pp. 25-40, is a noteworthy step in this direction.

In conclusion, it can be said that work along these lines should definitely be pursued, since the problems of growth can be severe and will be with us for some time to come. Our understanding of both the dynamics and appropriate control policies is quite minimal. A few steps have been taken in the direction of greater understanding, but they, at least, have revealed how poorly-understood some of these phenomena are.

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Appendix

Details of the Two Simulations

This appendix presents the more detailed results upon which the data in Table 23 of Chapter 6 are based. The simulation presents, in this case, data in five-year intervals, although yearly results could have been requested. It presents data from the SMSA model (jobs, households, housing) the school enrollment module (school-aged children and enrollments) and the budget module (town budget). Two simulations are conducted: one employs nominal assumptions about the growth of the region and the town, the second employs the same assumptions about the growth of the region, but stops all construction in Guilford after 1970.

The program is an interactive one -- these results are a copy of an actual console session. The responses of the user are underlined; all other printout is from the program.

The description and analysis of these results is treated in the last section of Chapter 6.

```
THIS IS THE GUILFORD TOWN PLANNING MODEL ... 30-Dec-74
A "=>" SIGN MEANS THAT THE MODEL IS WAITING FOR YOUR COMMAND
IF YOU HAVE ANY QUESTIONS, TYPE "HELP","H", OR "?"

=> DEBUG
SET OS SWITCHES?  N
SET IS SWITCHES?  Y
WHICH? 75
WHICH? 79
WHICH? 0

DO YOU WANT STANDARD INITIALIZATION (Y OR N)?    Y
=> ?

COMMANDS ARE...
   RUN              PERFORM A SIMULATION.
   REPORT           PRESENT RESULTS OF A SIMULATION AS TABLES, GRAPHS,
                        OR MAPS FOR FINAL YEAR OF A SIMULATION.
   CONTINUE         CONTINUE THE SIMULATION FROM CURRENT YEAR.
   CHANGE           CHANGE VARIABLES.
   SAVE             SAVE CURRENT DATA.
   RESTORE          INITIALIZE FROM PREVIOUSLY "SAVED"  SET OF DATA.
   QUIT             EXIT FROM TOWNPLAN.

=> TUN
COMMAND "TUN  " UNKNOWN. RETYPE IT, OR GIVE H OR ? FOR HELP, $ TO QUIT
INPUT AGAIN: RUN

IN WHAT YEAR DO YOU WANT SIMULATION TO START?    ?
ALLOWABLE STARTING YEARS ARE 1960,1961,1970.


IN WHAT YEAR DO YOU WANT SIMULATION TO START?    1960
IN WHAT YEAR DO YOU WANT THE SIMULATION TO END?  1980
DO YOU WANT REPORTS YEARLY (Y), EVERY FIVE YEARS (F), OR AT END (E)? F
WHAT DO YOU WANT REPORTS ABOUT?   ?
REPORTS ARE AVAILABLE FOR:
 JOBS BY INDUSTRY
 DEMOGRAPHY
 STOCK OF HOUSING
 SCHOOL AGE CHILDREN
 PUBLIC SCHOOL ENROLLMENT
 TOWN BUDGET (IN $MIL)
 ALL

TYPE ONE OF THESE NAMES FOLLOWED BY CARRIAGE RETURN TO SELECT.
END THE LIST WITH  0
WHAT DO YOU WANT REPORTS ABOUT?   ALL
SHOULD REPORTS GIVE DETAIL (D) OR BE TOTALS FOR GUILFORD (T)?  D
DO YOU WANT COMPARISON OF SIMULATED AND ACTUAL FIGURES (Y,N)?   Y
```

REPORTS FOR YEAR 1960

JOBS BY INDUSTRY

INDUSTRY	NUMBER OF JOBS	PERCENT OF TOTAL
NON-DURABLE MAN	456.	31.75
DURABLE MANUFAC	100.	6.96
CONSTRUCTION	84.	5.85
TRANSPORTATION	5.	0.35
COMM & UTILITY	1.	0.07
WHOLESALE SALES	12.	0.84
RETAIL SALES	367.	25.56
FIN/INS/REAL ES	39.	2.72
SERVICES	162.	11.28
GOVERNMENT	210.	14.62
TOTAL	1436.	100.00

DEMOGRAPHY

AGE	ETHNICITY	TOTAL HOUSE-HOLDS	PERCENT OF TOTAL
20-39	NATIVE	763.	32.87
	FOR+MIN	31.	1.34
40-64	NATIVE	992.	42.74
	FOR+MIN	106.	4.57
65+	NATIVE	314.	13.53
	FOR+MIN	115.	4.95
TOTAL		2321.	100.00

STOCK OF HOUSING

TENURE	PRICE	TOTAL STOCK	TOTAL OCCUPD UNITS	VACAN-CIES THIS YR	VACANCY RATE %	HOUSING STARTS THIS YR	STARTS % OF TOTAL
OWN	HIGH	311.	302.	9.	2.89	37.	11.90
RENT	HIGH	183.	175.	8.	4.37	0.	0.00
OWN	MED	741.	723.	18.	2.43	64.	8.64
RENT	MED	240.	238.	12.	5.00	0.	0.00
OWN	LOW	810.	800.	10.	1.23	0.	0.00
RENT	LOW	94.	83.	11.	11.70	0.	0.00
TOTAL		2379.	2321.	68.	2.86	101.	4.25

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	993.	168.	757.	646.	422.	72.	3059.
ACTUAL	962.	173.	763.	659.	441.	72.	3070.
DIFFERENCE	31.	-5.	-6.	-13.	-19.	0.	-11.
PERCENT ERROR	3.3	-3.0	-0.8	-2.0	-4.4	0.7	-0.4

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	172.	796.	425.	379.	1771.
ACTUAL	181.	790.	450.	370.	1791.
DIFFERENCE	-9.	6.	-25.	9.	-20.
PERCENT ERROR	-5.23	0.72	-5.61	2.33	-1.14

REPORTS FOR YEAR 1965

JOBS BY INDUSTRY

INDUSTRY	NUMBER OF JOBS	PERCENT OF TOTAL
NON-DURABLE MAN	942.	29.70
DURABLE MANUFAC	1014.	31.97
CONSTRUCTION	168.	5.30
TRANSPORTATION	193.	6.08
COMM & UTILITY	1.	0.03
WHOLESALE SALES	102.	3.22
RETAIL SALES	345.	10.88
FIN/INS/REAL ES	38.	1.20
SERVICES	159.	5.01
GOVERNMENT	208.	6.56
TOTAL	3172.	100.00

DEMOGRAPHY

AGE	ETHNICITY	TOTAL HOUSE-HOLDS	PERCENT OF TOTAL	CHANGE THIS YEAR	PERCENT CHANGE	INMIG-RATION (THIS	OUTMIG-RATION YEAR)
20-39	NATIVE	943.	32.11	64.	6.77	192.	129.
	FOR+MIN	24.	0.82	2.	8.57	5.	3.
40-64	NATIVE	1353.	46.07	67.	4.92	128.	62.
	FOR+MIN	130.	4.43	7.	5.30	15.	8.
65+	NATIVE	392.	13.35	-18.	-4.61	20.	38.
	FOR+MIN	95.	3.23	-9.	-9.59	1.	10.
TOTAL		2937.	100.00	112.	3.82	361.	249.

STOCK OF HOUSING

TENURE	PRICE	TOTAL STOCK	TOTAL OCCUPD UNITS	VACAN-CIES THIS YR	VACANCY RATE %	HOUSING STARTS THIS YR	STARTS % OF TOTAL
OWN	HIGH	596.	596.	0.	0.00	68.	11.41
RENT	HIGH	254.	251.	4.	1.57	0.	0.00
OWN	MED	1111.	1108.	3.	0.27	71.	6.39
RENT	MED	205.	196.	9.	4.39	0.	0.00
OWN	LOW	747.	747.	0.	0.00	0.	0.00
RENT	LOW	69.	38.	31.	44.93	0.	0.00
TOTAL		2982.	2936.	47.	1.58	139.	4.66

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1145.	208.	982.	818.	554.	99.	3805.

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	213.	1024.	538.	515.	2291.
ACTUAL	236.	1070.	504.	567.	2377.
DIFFERENCE	-23.	-46.	34.	-52.	-86.
PERCENT ERROR	-9.64	-4.32	6.76	-9.10	-3.64

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	1.526	1.642	-0.116	-7.0
STATE	0.494	0.458	0.036	7.8
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.080	0.059	0.021	34.9
TOTAL S,F,L	0.574	0.517	0.057	10.9
TOTAL REVENUE	2.100	2.159	-0.059	-2.7
EXPENDITURES:				
SCHOOLS	1.192	1.201	-0.009	-0.7
MAINTENANCE	0.174	0.184	-0.010	-5.4
DEBT SERVICE	0.274	0.269	0.004	1.5
NORM. CAPITAL	0.027	0.029	-0.003	-8.7
TOWN ADMIN.	0.154	0.183	-0.030	-16.2
PUBLIC SAFETY	0.181	0.174	0.008	4.5
HLTH/WLFR/RCN	0.099	0.100	-0.001	-0.9
TOTAL EXPEND.	2.100	2.140	-0.040	-1.9
TOTAL DEBT	2.365	2.167	0.198	9.2
MILL RATE	0.026	0.025	0.001	2.1
GRAND LIST	58.625	64.461	-5.836	-9.1

REPORTS FOR YEAR 1970

JOBS BY INDUSTRY

INDUSTRY	NUMBER OF JOBS	PERCENT OF TOTAL
NON-DURABLE MAN	758.	26.62
DURABLE MANUFAC	629.	22.09
CONSTRUCTION	122.	4.28
TRANSPORTATION	100.	3.51
COMM & UTILITY	1.	0.04
WHOLESALE SALES	64.	2.25
RETAIL SALES	511.	17.94
FIN/INS/REAL ES	46.	1.62
SERVICES	221.	7.76
GOVERNMENT	396.	13.90
TOTAL	2848.	100.00

DEMOGRAPHY

AGE	ETHNICITY	TOTAL HOUSE-HOLDS	PERCENT OF TOTAL	CHANGE THIS YEAR	PERCENT CHANGE	INMIG-RATION (THIS	OUTMIG-RATION YEAR)
20-39	NATIVE	1231.	34.37	80.	6.50	217.	137.
	FOR+MIN	60.	1.68	4.	5.95	7.	3.
40-64	NATIVE	1589.	44.36	63.	3.94	149.	86.
	FOR+MIN	115.	3.21	10.	9.08	18.	8.
65+	NATIVE	506.	14.13	-19.	-3.82	25.	45.
	FOR+MIN	81.	2.26	-9.	-11.15	1.	10.
TOTAL		3582.	100.00	128.	3.58	417.	289.

STOCK OF HOUSING

TENURE	PRICE	TOTAL STOCK	TOTAL OCCUPD UNITS	VACAN-CIES THIS YR	VACANCY RATE %	HOUSING STARTS THIS YR	STARTS % OF TOTAL
OWN	HIGH	1125.	1117.	8.	0.71	44.	3.91
RENT	HIGH	423.	370.	53.	12.53	0.	0.00
OWN	MED	1276.	1276.	0.	0.00	81.	6.35
RENT	MED	198.	198.	0.	0.00	0.	0.00
OWN	LOW	571.	540.	31.	5.43	0.	0.00
RENT	LOW	106.	82.	24.	22.64	0.	0.00
TOTAL		3699.	3583.	116.	3.14	125.	3.38

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1080.	247.	1439.	1190.	837.	127.	4920.
ACTUAL	1050.	247.	1446.	1204.	815.	123.	4885.
DIFFERENCE	30.	-0.	-7.	-14.	22.	4.	35.
PERCENT ERROR	2.8	-0.1	-0.5	-1.1	2.7	3.1	0.7

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	255.	1505.	791.	828.	3380.
ACTUAL	271.	1507.	803.	793.	3374.
DIFFERENCE	-16.	-2.	-12.	35.	6.
PERCENT ERROR	-5.95	-0.11	-1.50	4.47	0.17

TOWN BUDGET (IN $MIL)

	SIMULATED	ACTUALS	DIFFERENCE	PERCENT DIFFERENCE
REVENUES:				
PROPERTY TAX	3.473	3.552	-0.079	-2.2
STATE	0.955	0.996	-0.041	-4.1
FEDERAL	0.000	0.000	0.000	0.0
LOCAL	0.251	0.251	0.000	0.0
TOTAL S,F,L	1.205	1.247	-0.041	-3.3
TOTAL REVENUE	4.678	4.799	-0.121	-2.5
EXPENDITURES:				
SCHOOLS	2.686	2.688	-0.002	-0.1
MAINTENANCE	0.275	0.295	-0.020	-6.8
DEBT SERVICE	0.733	0.729	0.004	0.6
NORM. CAPITAL	0.095	0.116	-0.021	-18.2
TOWN ADMIN.	0.360	0.329	0.030	9.2
PUBLIC SAFETY	0.341	0.350	-0.009	-2.6
HLTH/WLFR/RCN	0.189	0.176	0.013	7.4
TOTAL EXPEND.	4.678	4.679	-0.001	-0.0
TOTAL DEBT	8.591	8.625	-0.034	-0.4
MILL RATE	0.041	0.041	0.000	0.4
GRAND LIST	84.354	87.026	-2.672	-3.1

REPORTS FOR YEAR 1975

JOBS BY INDUSTRY

INDUSTRY	NUMBER OF JOBS	PERCENT OF TOTAL
NON-DURABLE MAN	1135.	27.86
DURABLE MANUFAC	1288.	31.62
CONSTRUCTION	148.	3.63
TRANSPORTATION	215.	5.28
COMM & UTILITY	1.	0.02
WHOLESALE SALES	151.	3.71
RETAIL SALES	481.	11.81
FIN/INS/REAL ES	45.	1.10
SERVICES	217.	5.33
GOVERNMENT	393.	9.65
TOTAL	4074.	100.00

DEMOGRAPHY

AGE	ETHNICITY	TOTAL HOUSE-HOLDS	PERCENT OF TOTAL	CHANGE THIS YEAR	PERCENT CHANGE	INMIG-RATION (THIS	OUTMIG-RATION YEAR)
20-39	NATIVE	1463.	33.20	179.	12.24	361.	182.
	FOR+MIN	96.	2.18	20.	20.53	32.	12.
40-64	NATIVE	2008.	45.56	68.	3.36	163.	95.
	FOR+MIN	139.	3.15	13.	9.35	23.	10.
65+	NATIVE	617.	14.00	-36.	-5.81	19.	55.
	FOR+MIN	84.	1.91	-9.	-10.71	1.	10.
TOTAL		4407.	100.00	234.	5.32	600.	365.

STOCK OF HOUSING

TENURE	PRICE	TOTAL STOCK	TOTAL OCCUPD UNITS	VACAN-CIES THIS YR	VACANCY RATE %	HOUSING STARTS THIS YR	STARTS % OF TOTAL
OWN	HIGH	1639.	1630.	9.	0.55	137.	8.36
RENT	HIGH	489.	489.	0.	0.00	39.	7.98
OWN	MED	1555.	1538.	17.	1.09	74.	4.76
RENT	MED	172.	172.	0.	0.00	3.	1.74
OWN	LOW	525.	515.	10.	1.90	0.	0.00
RENT	LOW	79.	64.	15.	18.99	0.	0.00
TOTAL		4459.	4408.	51.	1.14	253.	5.67

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1138.	268.	1483.	1292.	1104.	165.	5449.

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	280.	1583.	918.	1150.	3931.

TOWN BUDGET (IN $MIL)

	SIMULATED
REVENUES:	
PROPERTY TAX	7.774
STATE	1.743
FEDERAL	0.000
LOCAL	0.359
TOTAL S,F,L	2.102
TOTAL REVENUE	9.876
EXPENDITURES:	
SCHOOLS	6.244
MAINTENANCE	0.408
DEBT SERVICE	1.345
NORM. CAPITAL	0.188
TOWN ADMIN.	0.755
PUBLIC SAFETY	0.592
HLTH/WLFR/RCN	0.343
TOTAL EXPEND.	9.876
TOTAL DEBT	16.883
MILL RATE	0.056
GRAND LIST	138.478

REPORTS FOR YEAR 1980

JOBS BY INDUSTRY

INDUSTRY	NUMBER OF JOBS	PERCENT OF TOTAL
NON-DURABLE MAN	1212.	25.47
DURABLE MANUFAC	1722.	36.18
CONSTRUCTION	184.	3.87
TRANSPORTATION	304.	6.39
COMM & UTILITY	1.	0.02
WHOLESALE SALES	236.	4.96
RETAIL SALES	450.	9.46
FIN/INS/REAL ES	44.	0.92
SERVICES	214.	4.50
GOVERNMENT	390.	8.19
TOTAL	4759.	100.00

DEMOGRAPHY

AGE	ETHNICITY	TOTAL HOUSE-HOLDS	PERCENT OF TOTAL	CHANGE THIS YEAR	PERCENT CHANGE	INMIG-RATION (THIS	OUTMIG-RATION YEAR)
20-39	NATIVE	2218.	37.01	271.	12.21	550.	279.
	FOR+MIN	194.	3.24	35.	18.02	64.	29.
40-64	NATIVE	2522.	42.08	75.	2.98	196.	121.
	FOR+MIN	229.	3.82	19.	8.43	39.	19.
65+	NATIVE	749.	12.50	-28.	-3.80	35.	64.
	FOR+MIN	81.	1.35	-5.	-6.19	4.	9.
TOTAL		5993.	100.00	367.	6.12	887.	521.

STOCK OF HOUSING

TENURE	PRICE	TOTAL STOCK	TOTAL OCCUPD UNITS	VACAN-CIES THIS YR	VACANCY RATE %	HOUSING STARTS THIS YR	STARTS % OF TOTAL
OWN	HIGH	2603.	2531.	72.	2.77	167.	6.42
RENT	HIGH	777.	777.	0.	0.00	68.	8.75
OWN	MED	2004.	2002.	2.	0.10	112.	5.59
RENT	MED	160.	160.	0.	0.00	1.	0.63
OWN	LOW	479.	479.	0.	0.00	0.	0.00
RENT	LOW	45.	45.	0.	0.00	0.	0.00
TOTAL		6068.	5994.	74.	1.22	348.	5.74

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	1619.	384.	1942.	1659.	1509.	218.	7331.

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	408.	2110.	1244.	1657.	5420.

TOWN BUDGET (IN $MIL)

	SIMULATED
REVENUES:	
PROPERTY TAX	12.702
STATE	3.289
FEDERAL	0.000
LOCAL	0.709
TOTAL S,F,L	3.998
TOTAL REVENUE	16.700
EXPENDITURES:	
SCHOOLS	11.552
MAINTENANCE	0.509
DEBT SERVICE	1.665
NORM. CAPITAL	0.174
TOWN ADMIN.	1.057
PUBLIC SAFETY	1.099
HLTH/WLFR/RCN	0.644
TOTAL EXPEND.	16.700
TOTAL DEBT	21.061
MILL RATE	0.058
GRAND LIST	220.798

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*> CHANGE

WHAT CHANGES DO YOU WANT TO MAKE? GROWTH

WHAT GROWTH OPTION?ZERO
NEXT CHANGE? 0
*> RUN

IN WHAT YEAR DO YOU WANT SIMULATION TO START?    1970
IN WHAT YEAR DO YOU WANT THE SIMULATION TO END?  1980
DO YOU WANT REPORTS YEARLY (Y), EVERY FIVE YEARS (F), OR AT END (E)? F
WHAT DO YOU WANT REPORTS ABOUT?   $
*> RUN

IN WHAT YEAR DO YOU WANT SIMULATION TO START?    1970
IN WHAT YEAR DO YOU WANT THE SIMULATION TO END?  1975
DO YOU WANT REPORTS YEARLY (Y), EVERY FIVE YEARS (F), OR AT END (E)? E
WHAT DO YOU WANT REPORTS ABOUT?   ALL
SHOULD REPORTS GIVE DETAIL (D) OR BE TOTALS FOR GUILFORD (T)?  D
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REPORTS FOR YEAR 1975

JOBS BY INDUSTRY

INDUSTRY	NUMBER OF JOBS	PERCENT OF TOTAL
NON-DURABLE MAN	1133.	27.90
DURABLE MANUFAC	1286.	31.67
CONSTRUCTION	138.	3.40
TRANSPORTATION	215.	5.29
COMM & UTILITY	1.	0.02
WHOLESALE SALES	151.	3.72
RETAIL SALES	481.	11.84
FIN/INS/REAL ES	45.	1.11
SERVICES	217.	5.34
GOVERNMENT	393.	9.68
TOTAL	4061.	100.00

DEMOGRAPHY

AGE	ETHNICITY	TOTAL HOUSE-HOLDS	PERCENT OF TOTAL	CHANGE THIS YEAR	PERCENT CHANGE	INMIG-RATION (THIS	OUTMIG-RATION YEAR)
20-39	NATIVE	1131.	29.76	23.	2.06	189.	166.
	FOR+MIN	63.	1.66	5.	7.61	14.	10.
40-64	NATIVE	1809.	47.59	10.	0.55	101.	91.
	FOR+MIN	111.	2.92	2.	1.60	10.	8.
65+	NATIVE	602.	15.84	-30.	-4.97	25.	54.
	FOR+MIN	85.	2.24	-6.	-7.30	4.	10.
TOTAL		3801.	100.00	4.	0.10	343.	339.

STOCK OF HOUSING

TENURE	PRICE	TOTAL STOCK	TOTAL OCCUPD UNITS	VACAN- CIES THIS YR	VACANCY RATE %	HOUSING STARTS THIS YR	STARTS % OF TOTAL
OWN	HIGH	1237.	1235.	2.	0.16	0.	0.00
RENT	HIGH	483.	483.	0.	0.00	0.	0.00
OWN	MED	1333.	1333.	0.	0.00	0.	0.00
RENT	MED	170.	170.	0.	0.00	0.	0.00
OWN	LOW	525.	516.	9.	1.71	0.	0.00
RENT	LOW	73.	66.	8.	10.96	0.	0.00
TOTAL		3821.	3803.	19.	0.50	0.	0.00

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	843.	206.	1200.	1085.	963.	148.	4444.

PUBLIC SCHOOL ENROLLMENT

	KINDER- GARTEN	ELEMEN- TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	213.	1273.	766.	997.	3248.

TOWN BUDGET (IN $MIL)

	SIMULATED
REVENUES:	
PROPERTY TAX	7.572
STATE	1.337
FEDERAL	0.000
LOCAL	0.242
TOTAL S,F,L	1.579
TOTAL REVENUE	9.151
EXPENDITURES:	
SCHOOLS	5.714
MAINTENANCE	0.419
DEBT SERVICE	1.496
NORM. CAPITAL	0.255
TOWN ADMIN.	0.545
PUBLIC SAFETY	0.458
HLTH/WLFR/RCN	0.264
TOTAL. EXPEND.	9.151
TOTAL DEBT	19.045
MILL RATE	0.062
GRAND LIST	121.568

=> CONTINUE
IN WHAT YEAR DO YOU WANT THE SIMULATION TO END? 1980
DO YOU WANT REPORTS YEARLY (Y), EVERY FIVE YEARS (F), OR AT END (E)? E
WHAT DO YOU WANT REPORTS ABOUT? ALL
SHOULD REPORTS GIVE DETAIL (D) OR BE TOTALS FOR GUILFORD (T)? D

REPORTS FOR YEAR 1980

JOBS BY INDUSTRY

INDUSTRY	NUMBER OF JOBS	PERCENT OF TOTAL
NON-DURABLE MAN	1198.	25.55
DURABLE MANUFAC	1700.	36.26
CONSTRUCTION	145.	3.09
TRANSPORTATION	306.	6.53
COMM & UTILITY	1.	0.02
WHOLESALE SALES	240.	5.12
RETAIL SALES	450.	9.60
FIN/INS/REAL ES	44.	0.94
SERVICES	214.	4.56
GOVERNMENT	390.	8.32
TOTAL	4689.	100.00

DEMOGRAPHY

AGE	ETHNICITY	TOTAL HOUSE-HOLDS	PERCENT OF TOTAL	CHANGE THIS YEAR	PERCENT CHANGE	INMIG-RATION (THIS	OUTMIG-RATION YEAR)
20-39	NATIVE	1004.	26.38	39.	3.90	190.	151.
	FOR+MIN	79.	2.08	9.	10.09	22.	14.
40-64	NATIVE	1864.	48.98	-2.	-0.12	94.	97.
	FOR+MIN	120.	3.15	2.	1.42	13.	11.
65+	NATIVE	655.	17.21	-37.	-5.57	20.	57.
	FOR+MIN	84.	2.21	-6.	-7.23	3.	9.
TOTAL		3806.	100.00	4.	0.11	342.	338.

STOCK OF HOUSING

TENURE	PRICE	TOTAL STOCK	TOTAL OCCUPD UNITS	VACAN-CIES THIS YR	VACANCY RATE %	HOUSING STARTS THIS YR	STARTS % OF TOTAL
OWN	HIGH	1305.	1292.	13.	1.00	0.	0.00
RENT	HIGH	534.	534.	0.	0.00	0.	0.00
OWN	MED	1310.	1310.	0.	0.00	0.	0.00
RENT	MED	146.	146.	0.	0.00	0.	0.00
OWN	LOW	482.	479.	2.	0.41	0.	0.00
RENT	LOW	46.	46.	0.	0.00	0.	0.00
TOTAL		3823.	3807.	15.	0.39	0.	0.00

SCHOOL AGE CHILDREN

	UNDER 5 YEARS	5 YEARS	6-10 YEARS	11-14 YEARS	15-18 YEARS	19 YEARS	TOTAL
SIMULATED	724.	187.	1068.	1012.	1022.	159.	4172.

PUBLIC SCHOOL ENROLLMENT

	KINDER-GARTEN	ELEMEN-TARY (1-5)	MIDDLE SCHOOL (6-8)	HIGH SCHOOL (9-12)	TOTAL
SIMULATED	197.	1157.	750.	1104.	3209.

TOWN BUDGET (IN $MIL)

	SIMULATED
REVENUES:	
PROPERTY TAX	11.817
STATE	1.571
FEDERAL	0.000
LOCAL	0.245
TOTAL S,F,L	1.816
TOTAL REVENUE	13.633
EXPENDITURES:	
SCHOOLS	8.739
MAINTENANCE	0.547
DEBT SERVICE	2.236
NORM. CAPITAL	0.415
TOWN ADMIN.	0.856
PUBLIC SAFETY	0.530
HLTH/WLFR/RCN	0.310
TOTAL EXPEND.	13.633
TOTAL DEBT	29.234
MILL RATE	0.079
GRAND LIST	148.904

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Biography

Peter Allaman was educated at Otterbein College, where he received a B.A. in 1963. He has studied mathematics at the Ohio State University, and holds the A.M. in sociology from Harvard University and the M.C.P. from M.I.T. Four years in the Air Force were spent in the areas of program budgeting and control and cost estimation. He has participated in a wide variety of research projects in the fields of: "modernization" in "underdeveloped nations," social psychology, physiology, information retrieval systems, and urban history. While in the doctoral program at M.I.T., he worked in the Dynamic Modeling Group at Project MAC, and as a Research Associate at the Harvard Business School. He has had the following awards: Harvard Scholarship, Mellon Fellowship (M.I.T.), Fellow - Joint Center for Urban Studies of M.I.T. and Harvard University. He is married, and his principal avocation is attempting to be a father to a very rapidly-growing young daughter.