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Ronald G. Cummings

Arthur F. Mehr

INVESTMENTS FOR URBAN INFRASTRUCTURE IN BOOMTOWNS

RONALD G. CUMMINGS and ARTHUR F. MEHR*

INTRODUCTION

The term boomtown is generally used to describe relatively small communities which are undergoing rapid and substantial changes in population growth and general levels of economic activity.[1] In most cases, boomtowns result from the sudden expansion of production efforts by an existing plant, or the location of a new plant or plants in or near the community. In the Rocky Mountain Region, boomtowns are primarily associated with the expansion and construction of facilities for the extraction and processing of minerals, particularly coal.[2]

To afford some perspective of the characteristics of boomtowns, the following describes conditions found in Sweetwater County, Wyoming during the 1970-74 period which resulted from the expansion of trona mining and the construction of the Jim Bridger Power Plant, built for the Pacific Power and Light and Idaho Power Companies.

Population and employment levels increased from 18,931 to 36,900 and 7,230 to 15,225 respectively. Mining employment increased from 1530 to 2650; construction employment increased from almost zero to 4200.[3] The quality of municipal and other local services declined markedly. In the State of Wyoming, the average doctor/population ratio is 1:1100; in Sweetwater County this ratio declined from 1:1800 in 1970 to 1:3700 in 1974.[4] Mental health

*Professor and Visiting Assistant Professor of Economics, The University of New Mexico, respectively. The authors express their appreciation for many helpful comments on the work to Ralph d'Arge, Daniel Gardiner, Charles Howe, Allen Kneese, James McFarland, and William Schulze. Financial support for this work was provided by the Los Alamos Scientific Laboratory.

1. Gilmore, *Boomtowns May Hinder Energy Resource Development*, 191 Sci., 535 (Feb. 13, 1976). ". . . in most boomtowns a 15 percent growth rate lends to institutional breakdown . . ." across all elements of the community structure.

2. Of course, not all boomtowns in the Rocky Mountain Region are related to energy development. For a description of the recreation-related boom in Pitkin County, Colorado, *see* J. Gilmore and M. Duff, *The Evolving Political Economy of Pitkin County: Growth Management by Consensus in a Boom Community,* U. of Denver Research Inst. (March 1974).

3. J. Gilmore and M. Duff, *The Sweetwater County Boom: a Challenge to Growth Management,* 4-6 U. of Denver Research Inst. (July 1974).

4. *Id.* at 16.

clinic caseloads increased eight-fold. In 1974, there was an estimated deficit of 128 schoolrooms in the county. Capital costs for providing schoolrooms are estimated to be on the order of $5100 per child; 1970-74 increases in assessed valuation for school districts was but $2100 per child, however.[5] By 1974, the deficit in the municipal facilities of water, sewerage, roads and electricity, for homesites was on the order of 1397 home sites; 4,599 mobile home spaces were needed. With little expansion in police facilities, crime rates increased by 60% between 1972 and 1973.[6]

These statistics are only the more apparent indicators of the social, institutional and economic disruptions that may attend rapid, large scale economic developments in small communities. Increased rates of alcoholism, broken homes and suicides were other manifestations of breakdowns in social order in Sweetwater County reported in Gilmore and Duff's seminal work concerning the "anatomy" of a boomtown.

Of course, not all mineral related developments result in chaotic disorder on a scale such as described above. For example, increased coal mining activity in Cuba, New Mexico during the 1970-74 period resulted in socio-economic impacts which seem to have been beneficial to all concerned.[7] Population and employment changes were small relative to those experienced in Wyoming, however, amounting to 45% and 73%, respectively, over the 1970-74 period. More importantly, perhaps, in the case of Cuba, there seemed to be substantial excess capacity in terms of municipal facilities prior to the boom or boomlet.[8]

Given current expectations for mineral developments in the Rocky Mountain Region; an eight-fold increase in coal production between 1976-1985 in northwest New Mexico alone,[9] and given the region's experiences in such places as Page, Arizona, Rock Springs, Wyoming and Craig, Colorado, the region has ample reason for concern in terms of management problems associated with the Sweetwater type of boomtown developments. It is thus with the examination of a subset of problems of this type that this paper will be concerned.

Given the threat to the general "quality of life"[10] in a community posed by an anticipated development project, the local government,

5. *Id.* at 24.
6. *Id.* at 19 and 21.
7. B. Ives and C. Eastman, *Impact of Mining Development on an Isolated Rural Community: The Case of Cuba, New Mexico,* N.M. Agric. Exp. Sta. Research Rep. 301 (August 1975).
8. *Id.*, Table II, at 6.
9. Federation of Rocky Mountain States, at 25 (July 1975).
10. *Supra* note 1, at 537.

taken here to be a municipality, faces a wide range of planning problems, among which are investment plans for the provision of urban infrastructure. Urban infrastructure refers to capital investments by the municipality for such things as school, police and fire facilities, streets and roads, parks, sewage disposal and potable water facilities. Planning and executing such investment is an important problem for boomtowns and relatively little is understood about it.[11]

In looking at the problem of providing urban infrastructure in a community, it is useful to consider three interrelated sub-problems. First, one may encounter considerable difficulty in calculating or estimating the magnitude of population changes over time. Even if relatively reliable projections of the labor force required for the construction and operation of the development in question are available, the magnitude of additional in-migration induced by the development (in hopes of finding employment in the primary plant, or in secondary or tertiary activities) may be extremely difficult to estimate.[12]

Second, there is the problem of obtaining adequate and timely funds for financing investments in urban infrastructure. Aspects of this problem include the so-called "front-end" problems of taxes and funds derivable from the development which do not accrue to the municipality until after operations have begun; after the construction period, and problems associated with limitations on the bonding capacity of the municipality.[13]

Third, one encounters the dual problem of defining demands for urban infrastructure and, once defined, determining how much or how many of these demands are in fact to be satisfied; how much "should" be invested. This problem becomes particularly thorny in cases where anticipated population changes take on the form exemplified in Figure I. In many cases a large and rapid increase in population will attend the construction phase of a development, which may

11. A number of papers concerning these problems were presented at the Seminar on Financing Infrastructure in Energy Production Areas, sponsored by the Rocky Mountain Inst. for Policy Research, Snowbird, Utah, August 21-22, 1975: e.g., E. ALLEN and L. HANSEN, FINANCING INFRASTRUCTURE IN ENERGY PRODUCTION AREAS [hereinafter cited as *Allen and Hansen*].

12. Little of such induced in-migration occurred in the above referenced Cuba experience, while Sweetwater County experienced considerable immigration of this type. Another dimension of the demand-projection problem is the uncertainty surrounding a proposed development. *See Allen and Hansen, supra* note 11.

13. *Supra* notes 3 and 11, and A. Leholm, F. Leistrits, and T. Hertsgaard *Fiscal Impact of a New Industry in a Rural Area: A Coal Gasification Plant in Western North Dakota*, presented at the Seventh Annual Meeting, Midcontinent Section, Regional Services Ass'n., Duluth, Minn., at 10 (June 13-14, 1975).

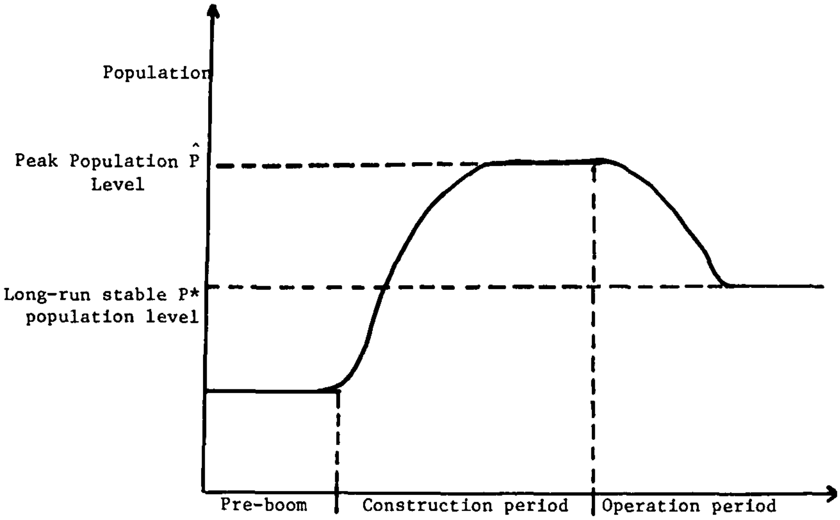

FIGURE I

Boomtown Population Over Time;
A Hypothetical Representation

extend from 4 to 8 years, after which population declines to a level related to the permanent labor force required for the operation of the facility. Also, the permanent labor force is often made up of individuals other than those in the community during the construction phase. Does the municipality attempt to meet infrastructure demands of the peak population P̂, which then implies the possible existence of substantial idle capacity at the end of the construction phase,[14] or does one plan for levels of urban infrastructure for the long run stable population P̂, which may imply a substantial deterioration in the quality and/or availability of infrastructure-related services during the construction period? Or, is there some middle ground, some optimal combination of after-the-construction-period idle capacity and during-the-construction-period deterioration of services?

The discussions that follow will be limited to analysis of the third problem outlined above. How do we determine an optimal investment strategy for investments in urban infrastructure? This limitation is primarily due to two considerations. First, given editorial limitations on the size of papers, it seems preferable to examine a few problems in some depth rather than attempt to treat many problems superficially. Second, the first and second problems have re-

14. This is the "solution" implied in Gilmore's work; *supra* note 1, at 538.

ceived considerable attention in the literature to date,[15] whereas relatively little has been said about problems of investment strategy.

In addressing the optimal investment problem the balance of this paper is organized in the following fashion. First, we identify the principal components of the investment strategy problem, and examine the state of the art in terms of our understanding of how to come to grips with it. Central to these discussions is the dismaying poverty of our conceptual and data base for this problem. Therefore, we will attempt to define the critical areas of research which are required if we are to make progress in efforts to provide a systematic method for analyzing investment alternatives for urban infrastructure. Secondly, we present some very tentative results from our ongoing research efforts in this field. These provide limited insights into some of the principal components of this problem. They also establish some basis for optimism as to the potential rewards for further research in identified areas. Concluding remarks are presented in the last section.

AN INVESTMENT STRATEGY FOR THE PROVISION OF URBAN INFRASTRUCTURE

An Overview of an Investment Strategy

In looking to a strategy for investments in social infrastructure, we begin by considering the flow diagram given in Figure II. It suggests a basic structure for the investment process upon which we will try to build a systematic approach to the analysis of the conceptual and empirical problems of optimal investment in boomtowns. In what follows, numbers in parentheses refer to the sequential "decision paths" identified in Figure II.

Taking as given population estimates for any given year in the community's planning horizon our path (1) involves the comparison of population to community determined goals or standards regarding urban infrastructure. Examples of such goals include desired student/classroom ratios (imposed by state/federal law in many cases), and per capita public safety facilities. Application of these goals or standards to population estimates results in estimates of "desired" levels for each type of capital.

15. *See, Allen and Hansen supra* note 11; Leholm, *supra* note 13; Environmental Protection Agency, *Socio-economic Input and Federal Assistance in Energy Development Impacted Communities in Federal Region VIII,* Comm. on Socio-economic Impacts, Mountain Plains Fed. Region Coun. Region VIII, Denver (July 1975); Kee, *Industrial Development and Its Impact on Local Finance,* 8. Q. Rev. Econ. & Bus. 19-24 (1968); Loewenstein, *The Impact of New Industries on the Fiscal Revenues and Expenditures of Suburban Communities,* 6 NAT'L TAX J. 113-129 (1963).

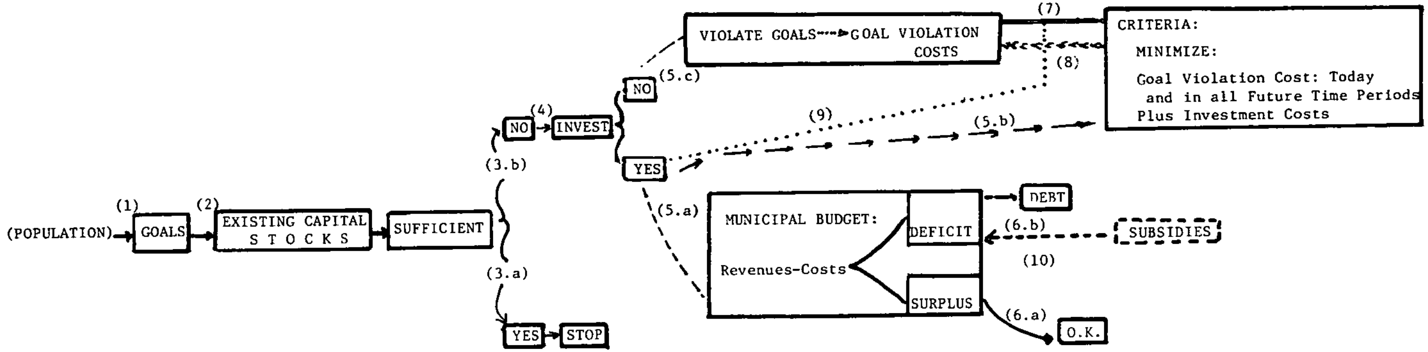

FIGURE II

Flow Chart for an Investment Strategy

Following path (2), desired capital stocks are compared with existing stocks. If existing stocks meet community goals (3.a), our process for this period terminates. If there is a deficit (3.b), we are then faced with making a determination as to whether or not to invest (4).

Before proceeding we must establish the community's criteria for investments in urban infrastructure. The criteria developed here may be viewed as surrogates for a wide range of other criteria relevant for investment decisions. We assume that the community wishes to minimize the sum of investment costs plus costs referred to as "goal violation costs." Goal violation costs refer to the social costs associated with the failure to maintain capital stocks at their desired, goal-determined levels as identified in path (1). The trade-off between these two costs are obvious; lower investment costs imply higher goal violation costs and vice versa.

A decision to invest then implies that investment costs are low relative to goal violation costs (paths 5.a and 5.c). Further, the investment decision must be consistent with municipal budgeting constraints. If deficit spending is involved (path 6.b, if not, 6.a) we must consider restrictions related to the community's capacity to incur debt (6.b). This restriction may be relaxed via external subsidies (path 10) in the form of, for example, state/federal grants. As previously stated, we do not analyze this aspect of the investment problem in this paper.

A decision not to invest (5.c) introduces goal violation costs which will occur in the present year as well as in all or some future years, and which relate directly to our criterion for investments in urban infrastructure (7). As was the case in the decision to invest, of primary importance are the costs of goal violations and investments (paths 5.b, 7 and 8, 9) relative to each other.

The criterion implicit in the system described in Figure II is thus one wherein investments in urban infrastructure are carried to the point where the costs associated with the last increment in investment just equals the increment in the present value of all relevant future goal violation costs. Further investments would add more to investment costs than they would subtract from goal violation costs; a lower investment level would increase goal violation costs through time more than it would decrease total investment costs.

Before we can proceed to try to make these criteria operational, we must consider the question: how may new community goals or standards and goal violation costs be established quantitatively?

Goals and Goal Violations

Let us begin by considering a goal of the form "the student/classroom ratio should not exceed 30:1." The question then is what are the consequences of violating this goal. What does it mean if these ratios reach 35:1, 50:1, or even 100:1?[16]

In several recent studies concerning the quality of education in which the indicator of quality is taken to be students' performance on examinations, an attempt has been made to correlate the quality of education with such things as class size, post baccalaureate training of teachers and physical facilities; one component of our urban infrastructure.[17] The most recent of these studies suggests that small class sizes of 28 students or less benefit only the disadvantaged students, while all other students' performance seems unaffected by much larger class size. In terms of physical facilities for education, there seems to be little or no correlation between student performance and capital investments.[18]

But further, even if one could identify a strong correlation between student performance and capital investments, the problem remains of translating altered performance resulting from alternative investment programs into some qualitative or quantitative evaluation of benefits and/or costs. What are the implications of a 5% increase or decrease in examination performance? What are the benefits, and to whom do they accrue, of a base-plus or minus score?

This line of inquiry can quickly lead one into a morass of philosophical and value related issues which have been discussed at considerable length by others.[19] In the end, we are left with no logically consistent, defensible way to associate costs and benefits with alternative levels of capital investments in educational facilities including the level consistent with oft-times legally determined standards.[20]

In somewhat different forms, arguments similar to those above

16. One interesting dimension of this issue is reflected in the findings of a survey by Gilmore that "the quality of sanitation service, road and street maintenance, schools, and shopping facilities (in the Rock Springs boom community) were deemed low enough that each justified leaving the community, in the opinion of a third of the newcomer households queried." *Supra* note 1, at 539.

17. E. Tamplyn, *Inequality: a Portrait of Rural America,* Rural Educ. Ass'n (1973); W. Mullenkopf and D. Melville, *A Study of Secondary School Characteristics as Translated into Test Scores,* Educational Testing Service, Research Bull. 56-6 (1956). For an interesting legal controversy concerning the quality of education, *see Rodriquez et al v. San Antonio Independent School District et al,* 411 U.S. 1 (1975), and *Serrano v. Priest,* 5 Cal. 3d 584, 487 P.2d 1241 (1971).

18. Summers & Wolfe, *Some School Resources Help Some Students to Learn, but Which?,* 36 Tax Rev. 37 (1975).

19. A. Thomas, *Efficiency in Education: a Study of the Relationship Between Selected Inputs and Mean Test Scores in a Sample of Senior High Schools* (unpublished Ph.D. thesis, Stanford University, Palo Alto, 1968); *Schools and Inequality,* J. W. Guthrie, et al., ed's (1971); U.S. Off. of Educ., *Equality of Education Opportunities* (Coleman et al., eds., 1966).

20. *Rodriguez v. San Antonio Independent School District, supra* note 17.

apply to all other types of urban infrastructures: recreational facilities, streets and roads, police facilities. They also apply, to a lesser extent, to fire protection facilities.[21] It would then seem that prospects for successfully measuring goal violation costs associated with capital investment levels are not encouraging.[22]

There is, however, an interesting line of research by Dr. Irving Hoch at Resources for the Future[23] concerning the relationship of wage differentials to city size which can be adapted to our problem. His methodology suggests a possible approach to an indirect measure for the subjective valuation of urban infrastructure. This approach involves viewing wage differentials between boomtowns and stable communities as measuring, at the margin, the premium required to compensate workers for accepting a lower quality of life. One component in this quality of life differential is taken to be the services provided by urban infrastructure—schools, public safety, etc.[24] The authors are currently in the process of attempting to empirically test these relationships and preliminary results as they relate to evaluating the potential of this approach for use in investment planning as discussed in the following section.[25]

Summary

In this section we have outlined a conceptual investment strategy which, if made operational, might well serve as a useful analytical tool to planners in boomtown communities. As a conceptual tool, the suggested strategy is reasonably straightforward and poses no

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21. In the case of fire facilities, fire insurance rates do seem to vary with municipal facilities, in which case insurance rate differentials, taken to measure changes in the expected value of fire losses, may be a useful surrogate for benefits or costs associated with alternative investment levels for fire protection.

22. Benefits associated with public goods in general have been studied; D. Bradford, *Benefit Cost Analysis and Demand Curves for Public Goods,* 23 KYLOS 775 (1970). Also, interesting attempts have been made to measure esthetic values: D. Brookshire, B. Ives, and W. Schulze, *The Evaluation of Aesthetic Preferences,* S.W. Regional Project Working Paper Ser., Dep't. of Econ., U. of N.M., Albuquerque, N.M. (no date).

23. *See* I. Hoch, *Urban Scale and Environmental Quality, Population, Resources and the Environment* (R. Ridker, ed.), Comm. on Population Growth and the Am. Future, 3 Research Rep. (1972), and *Variations in the Quality of Urban Life Among Cities and Regions,* paper presented in the Int'l Research Conf. on Public Policy and the Quality of Life in Urban Areas, New Orleans, La. (Jan. 2-7, 1975). We are particularly indebted to Prof. Ralph d'Arge for his suggestions which led us to this approach, and to Dr. Hoch for his suggestions and comments.

24. This assumption is clearly consistent with Gilmore's findings *supra* note 16.

25. A problem which is relevant to the measurements of goal violation costs is the fact that many different kinds of capital stocks may serve to provide any one given infrastructural service. This aspect of the investment issue of course compounds the difficulties of the measurement problems discussed above.

real structural problem in terms of computational complexities.[26] The critical problems have been shown to lie in the dearth of the conceptual tools and data which are prerequisites to any effort to analytically evaluate alternative investment patterns. We cannot find an operationally significant definition for a "quality of education," for example, let alone measure the relationship between quality and investments.

This is to suggest that high potential payoffs might well accrue to future research which focuses on this particularly knotty set of questions: what are the measurable gains to a community or society which may be attributed to investments in urban infrastructure? Without such measures, how does the municipal planner know whether an investment project under consideration is worthwhile or not, and how does he compare the worthiness of this project to other possible investment projects; for example, whether to build a school, or build additional recreational facilities? From the studies that we have reviewed, these decisions are largely based on the notion of standards, or goals. One attempts to maintain x dollars per capita or x facilities of various types invested in various types of infrastructure. This is the basic requirements approach to investment planning which leads to policy prescriptions that suggest, for example, the retardation of growth so that such requirements or standards may keep pace with the rate of economic development in the community.[27]

Obviously, the requirements approach is based on a particularly crucial assumption, *viz.*, that a society wishes to maintain these goals at any cost; in other words, this approach tacitly assumes that trade-offs do not exist between the maintenance of normal levels of infrastructure related services and other socio-economic quantities including income and employment, tax burdens, etc. This assumption is particularly critical in boomtown circumstances wherein peak demands for urban infrastructure may be relatively short lived, and where provision of norm-level infrastructure for the peak periods may well imply the existence of substantial amounts of idle capital after the peak.

Our arguments are based on the premise that these trade-offs do indeed exist; the problem is that of measuring benefits attributable to urban infrastructure which then, in conjunction with known capital costs, may be used within a trade-off context to optimize investment levels.

26. The structure of the investment problem as given here is easily adaptable to linear and/or dynamic programming algorithms.

27. *See generally*, Gilmore *supra* note 1.

These arguments have led us to the exploratory efforts to measure such infrastructure related benefits alluded to above, and it is on a brief description of these efforts that we now focus attention.

TOWARDS A MEASURE OF BENEFITS ATTRIBUTABLE TO URBAN INFRASTRUCTURE

As suggested in the above discussions, efforts to directly measure benefits/costs associated with infrastructure must seemingly await further theoretical and empirical research, reflecting the relative poverty of the current state of the arts in this area. In what follows, we wish to briefly lay out an indirect method for measuring benefits from urban infrastructure with which the authors are currently experimenting.

The conceptual basis for this method is relatively simple. We begin by constructing a composite, representative, community which is taken to represent normal or base conditions for community living in the region. In our work, this base town is a composite of six New Mexico communities which have experienced relatively mild rates of growth—2% to 3%—over the 1965-74 period. Our base town is characterized by measures or urban infrastructure per capita for education, public safety, water and sewerage, recreational facilities, and "all other"[28] which, as more or less average regional characteristics, are viewed as desired investment levels. A composite weekly wage, by occupation, is developed which is taken to measure the opportunity cost of labor. Per capita infrastructure and wages for our base town are given in Table I.[29]

We then hypothesize that, at the margin, a wage differential is required to compensate workers for the difference in the quality of life between boomtowns and our base town; in order to attract and retain labor in the boomtown community, labor must receive their base wage plus a premium which reflects differences in the quality of their living environment relative to the base community. Surrogates used to measure quality of the living environment are initially taken to be per capita infrastructure and the boomtown community's rela-

28. The "all other" capital category is simply a catch-all for investments other than those identified by K_1 through K_4; investment expenditures which could not be classified as to purpose, which include all investments from revenue sharing funds, were placed in this category.

29. A problem with which we have yet to attempt to deal concerns the possibilities of economies of scale associated with urban infrastructure; our limited data, used for the structure of base-towns given in Table I, suggest such scale economies. A number of authors, however, argue that such economics are non-existent. *See, e.g.*, Morgan and Hackbart, *An Analysis of State and Local Industrial Tax Exemption Program,* S. ECON. J. 200 (Oct. 1974).

TABLE I

BASE TOWN CHARACTERISTICS
PER CAPITA INFRASTRUCTURE (1965 DOLLARS)

Population Level	*Education*	*Public Safety*	*Water/ Sewerage*	*Recreation*	*"All Other"*
0-3000	$425	$245	$200	$ 75	$350
3001-15000	650	167	184	109	350
15000-over	474	140	184	114	350

Base-Town Weekly Wages for:	*Year*	*Mining*	*Construction*
	1965	$118.73	$105.30

Source: Capital Infrastructure data for New Mexico was computed from town budgets and New Mexico School Financial Reports from Data Bank at UNM.
Wage data was computed from the Covered Employment Data published by the Employment Security Commission in New Mexico and Colorado.

tive distance from a metropolitan area, a surrogate for relative isolation. We acknowledge the wide range of other arguments that might well be relevant for explaning wage differentials between base and boomtown communities, some of which are discussed in the concluding section of this paper. Our initial hypothesis is simply a tool for initial efforts to determine whether or not we can indeed identify a subjective valuation of urban infrastructure by individuals.

We define w^* as the difference in wages between boomtowns and our base community, K_i^* as the differential in per capita urban infrastructure of type i; e.g., educational facilities between the boomtown and base community, D as the differential in terms of distance to the metropolitan areas of Albuquerque, El Paso and Denver in our initial efforts, and E as the percentage change in employment from the preceding year in the boomtown. It represents a variable used to reflect instability in labor markets. We then form the following two sets of equations:

$$\text{A. } w^* = \text{constant} + \alpha_1 \sum_{i=1}^{5} K_i^* + \alpha_2 D + \alpha_3 E \qquad (1)$$

$$\alpha_4 \sum_{i=1}^{5} K_i^* + \alpha_5 \left(\sum_{i=1}^{5} K_i^*\right)^2 + \alpha_6 D + \alpha_7 D^2 + \alpha_8 E + \alpha_9 E^2 \qquad (2)$$

$$\text{B. } w^* = \text{constant} + \sum_{i=1}^{5} \beta_i K_i^* + \beta_6 D + \beta_7 E \qquad (3)$$

$$w^* = \text{constant} + \sum_{i=1}^{5} \hat{\beta}_i K_i^* + \sum_{i=1}^{5} \hat{\beta}_{5+i} K_i^{*2} + \hat{\beta}_{11} D + \hat{\beta}_{12} D^2 + \hat{\beta}_{13} E + \hat{\beta}_{14} E^2 \qquad (4)$$

Multiple regression techniques are then used to test the hypotheses implied by equations (1) – (4),[30] wherein data for 28 towns are used; 19 of these towns are in New Mexico, 9 in Colorado.[31] In the set A we look to the wage differential as being explained by differentials in total capital stocks per capita. We do not attempt to break out specific capital items. Equation (1) in set A implies that this relationship is linear; per capita capital stock differentials and wage differentials vary in some fixed proportional manner. In equation (2), this relation is taken to be quadratic; as the per capita stock differential increases, the wage differential increases at an increasing rate.

Using linear (3) and quadratic (4) structural forms, set B represents our efforts to attribute wage differentials to specific types of social infrastructure.

Before presenting the results from our initial efforts to test the above described hypotheses, we wish to reemphasize the caveats which must be kept in mind in interpreting the results. As with most exploratory efforts of this kind wherein one faces enormously costly data collection requirements vis-a-vis limited time and financial resources, the first phase of the research is designed to provide a basis for evaluating little more than the potential of the methodology. Of primary concern is the question: do the results from preliminary analyses suggest that the promise of this methodology is sufficient to warrant the expenditures of time and other resources required to refine the data and method? Thus, data used to generate the results described below are weak in a number of ways, and the results must therefore be interpreted as being nothing more than suggestive in terms of the degree to which wage differentials are indeed explained by infrastructure differentials between boom and base towns.

To provide the reader with a somewhat more specific notion as to the kinds of problems which underlie the data used in our initial efforts some major problems are briefly described as follows:

A. Annual estimates for capital stocks in boom and base communities simply do not exist. We have taken base town capital stocks to be the capitalized value of average annual investment expenditures over the period 1965-74. This procedure tacitly assumes, among other things, that no improvements in the quality of urban infra-

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30. Technically speaking, our hypotheses concern the values of the coefficients a and B. We hypothesize, e.g., a, B = o at some confidence level. *See* A. Mehr, *Measuring Social Benefits Attributable to Urban Infrastructure in Boomtowns* (unpublished Ph.D. dissertation, U. of R.I. 1976).

31. In obtaining parts of these data, we are required to observe state disclosure laws, in which case we do not at this point identify specific towns included in our sample.

structure occurred over this period, and ignores the possibility that observed investments in our base town set may have been associated with the introduction of totally new capital systems, as opposed to replacement and depreciation of existing systems. Boomtowns are then given base town per capita capital stocks in the initial year of the boom, after which capital stocks are increased by reported investment expenditures; this procedure, of course, almost consistently under or overestimates initial boomtown capital stocks. These are but a few of the problems encountered in efforts to estimate community capital stocks.

B. Wage and employment data which are readily available are for counties. We use data for construction and mining industries in an effort to focus on employment likely to be found in the communities of interest, with questionable success. Further, wages are in fact measures of total earnings divided by the labor force. Wage measurements then are subject to biases resulting from such things as periodic changes in unemployment resulting, in some cases, from strikes, earnings from overtime work, etc.

The above items are in fact nothing more than the tip of the iceberg in terms of problems which remain for consideration in future attempts to refine our measurements for critical parameters in our study, and serve to prepare the reader for an appreciation of first, the tentative character of our first phase results, and second, the planned direction of our future efforts in this line of research. With these considerations in mind, attention may now be turned to an examination of the results from our initial regression trials.

Results from the set A hypotheses, wherein wage differentials are taken to be explained by total per capita capital stocks, are given in Table II. The statistical significance of the regressions is given by the R^2 measures. Loosely interpreted, the R^2 measures (e.g., $R^2 = .30$ for equation A.1) means that the included variables explain some 30% of the total variation in wage differentials. The t-statistic for each coefficient is given in parenthesis under the coefficient. Conventional levels of significance for coefficients are achieved for t-values greater than 1.8. Economists generally consider such coefficients with t-statistics greater than 1.8 as being significantly greater than zero.

From Table II, total capital stocks, relative distance to a metropolitan area, and percentage employment changes are seen to explain 30% to 50% of observed wage differentials (the R^2 term for A.1 and A.2). Total per capita capital stock differentials and relative distance are highly significant in explaining these wage differentials in the linear case (A.1), where weekly wage increases of \$.04 are implied

TABLE II

REGRESSION RESULTS FOR SET A HYPOTHESES

Equation A.1

$$w^* = \underset{(2.6)}{12} - \underset{(-3.6)}{.04}\ (\sum_{i=1}^{5} K_i^*) + \underset{(5.9)}{.17D} - \underset{(-.5)}{.014E}$$

$$R^2 = .30$$

Equation A.2

$$w^* = \underset{(-1.2)}{-9.6} - \underset{(-2.5)}{.049}\ (\sum_{i-1}^{5} K_i^*) \underset{(-.25)}{-.00001}\ (\sum_{i=1}^{5} K_i^*)^2$$

$$\underset{(-1.1)}{-.05D} + \underset{(6.2)}{.002D^2} + \underset{(2.5)}{.2\,E} - \underset{(-2.6)}{.0003E^2}$$

$$R^2 = .5$$

for each dollar that per capita capital stocks in the base town exceed those in the boom community. The significant linear relationship between total per capita infrastructural capital and wage differentials is also manifested in the quadratic structure (A.2); the squared term t is an insignificant .25 for the coefficient for $\Sigma K_i{}^2$, whereas the linear t term is a significant 2.5.

Experiments with sub-sets of the 28 town basic data pack, focusing on New Mexico towns only by population size and cross-sectional data, support the significance of this linear relationship between capital and wage differentials with R^2 measures ranging from 30 to 80 per cent. The weaknesses of our data notwithstanding, this argument seems to be a strong one, and we are encouraged to push this line of argument further.

In Table III the results of our regressions for set B are presented wherein we attempt to attribute wage differentials to per capita differentials in specific types of urban infrastructure. In the linear regression (B.3), included variables explain some 40% of observed wage differentials (R^2 = .4). In equation (B.3) wage differentials are seen to vary significantly with infrastructure differentials for education, public safety, and "all other."

Looking to the quadratic regression (B.4), linear and squared terms are significant for: education, water and sewerage, and percent employment changes; only squared terms are significant for "all other" and distance. In contrast to the linear relation discussed above, the structure of the non-linear relation between "all other" and wage differentials is consistent with our basic hypothesis. Also,

TABLE III

REGRESSION RESULTS FOR SET B HYPOTHESES

Equation B.3

$$w^* = \underset{(1.7)}{7.8} - \underset{(-3.9)}{.17K_1^*} - \underset{(-2.8)}{.25K_2^*} - \underset{(-1.1)}{.04K_3^*} - \underset{(-.2)}{.04K_4^*}$$

$$+ \underset{(2.7)}{.16K_5} + \underset{(7.0)}{.2D} - \underset{(-.3)}{.009E}$$

$$R^2 = .4$$

Equation B.4

$$w^* = \underset{(-1.7)}{-11.5} - \underset{(-3.7)}{.2K_1^*} - \underset{(-2.3)}{.001\ K_1^{*2}} - \underset{(-1.6)}{.17K_2^*} - \underset{(-.1)}{.00002K_2^{*2}}$$

$$+ \underset{(2.5)}{.23K_3^*} \underset{(-1.9)}{-.001K_3^{*2}} + \underset{(.17)}{.048K_4^*} - \underset{(-1.0)}{.005K_4^{*2}} \underset{(-.2)}{-.02K_5^*}$$

$$\underset{(2.5)}{-.005K_5^{*2}} - \underset{(-.9)}{.04D} + \underset{(6.9)}{.002D} + \underset{(2.4)}{.18E} - \underset{(2.4)}{.0003\ E^2}$$

$$R^2 = .64$$

the impact of instability in labor markets represented by the E variable in explaining wage differentials is significant in the quadratic expression in contrast with the linear structure.

A number of anomalies are apparent in comparing equations (B.3) and (B.4), in addition to those discussed above. In terms of explaining wage differentials, facilities for public safety are significant in the linear structure (B.3), non-significant in the quadratic expression (B.4); facilities for water and sewerage are insignificant in (B.3), significant in (B.4).[32] Capital facilities for recreation are the only variables for which coefficients are insignificant in both tests.

Our analyses to date then suggest the following tentative conclusions. The notion that wage differentials can be attributed to urban infrastructure differentials between boomtown communities and some norm is strongly supported. If then our goal was to generate measures for goal violation costs as they relate to total investments in urban infrastructure, leaving aside questions related to the optimal mix for types of infrastructure, the results of our linear analyses might well serve as a useful surrogate measure for the community's subjective valuation of these costs.

Our attempts thus far to get at the optimal mix problem by the

32. A further counterintuitive result relates to the negative sign on the squared terms for education and water/sewerage, which imply that wage differentials increase at a decreasing rate as capital differentials get increasingly large.

disaggregation of total capital stocks into their various functional types and associate wage differentials with each type of infrastructure are still at a very formative stage as is obvious from the results reported in Table III. Interestingly enough, our analyses consistently indicate significant relationships between wage differentials and educational facilities, while significant relationships between wage differentials and other capital types are still somewhat questionable. This observation may suggest that individuals are particularly concerned with educational facilities, while all other types of urban infrastructure are seen as a gestalt reflecting the general quality of the living environment in the boom community. This is strictly conjectural at this point, but may serve as a useful line of inquiry at later stages in our analyses.

CONCLUDING REMARKS

Clearly a great deal of work remains in terms of our efforts to develop benefit measures for urban infrastructure[33] which might be used in investment planning models such as that sketched out in Figure II. In closing we would like to point out some of the directions for further extensions and/or refinements of this work which appear to be most promising in terms of increasing the potential richness of our suggested approach.

First, our efforts to correlate wage differentials to disaggregated infrastructure types may be enhanced by the introduction of other variables in our regression system. A prime candidate may well be some measure of private capital expenditures in the boom community. Certainly the results of Gilmore's survey suggest that such private capital related things as shopping centers and facilities are of paramount concern to boomtown dwellers, not to mention such other things as the availability of housing.[34] To some extent, our "distance" variable D may reflect such things as feelings of relative isolation, costs of acquiring medical care, access to air travel facilities, and other considerations related to convenience. Thus, efforts to disaggregate the distance variable, as well, perhaps, as to include other private capital related items such as housing may have high potential pay offs in terms of improving our estimates of capital-related changes in wage differentials.

Second, there are undoubtedly a number of variations of our basic hypothesis which may result in better estimates of infrastructure

33. The author's project, funded by the Los Alamos Scientific Laboratory, is scheduled to be completed by August 1977.

34. *Supra* note 1. We are particularly grateful to Allen Kneese for his many helpful suggestions concerning the directions for future research.

related benefits. One with which we are currently experimenting is that wage differentials are explained by expected differentials in capital infrastructure. Again, there are a number of ways by which one may choose to measure expected capital differentials. We assume that pre-boom absolute levels of capital stocks obtain over the 4 to 8 year construction period, in which case, with rapidly increasing population, capital stocks per capita decline rapidly. The assumption that no net investment takes place over the construction period, as a method of imposing one measure of expected infrastructural differentials, is consistent with the front-end problem faced by many boomtown communities. This is simply to say, however, that alternative hypotheses related to the wage differential argument may profitably serve as lines of future research inquiry.

Third, wage differentials are used in our work to date apply only to construction and/or mining employees. It is not at all clear that benefit/cost measures which result from the manipulation of these data are appropriate measures of infrastructure-related benefits/cost for the community's total population. A number of complex conceptual issues arise here; a particularly thorny one concerns questions as to the relative valuation of costs attributable to deteriorated services from urban infrastructure between highly mobile families, mining and construction workers in some instances, and older, "permanent," and non-mobile members of the community.

Finally, a particularly interesting topic for future research might be how the institutional context for decision making may influence the outcome. Does it matter whether the community is a government or private company town, whether it is a unit development which is not a company town, or whether it is an ordinary disorganized community?[35]

These and many other issues remain for exploration in terms of the line of research suggested here. Our hope is that in reporting the state of our progress in this regard (or perhaps, the state of our confusion), others may be stimulated to direct their thoughts and imagination to the end of providing these critical measures of infrastructure-related benefits and costs.

35. This topic was suggested to the authors by Professor Allen Kneese, U. of N.M.