A THEORETICAL FRAMEWORK FOR RURAL COMMUNITY DEVELOPMENT*

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Introduction

Issues associated with the "optimal" geographic distribution of population and economic activity have long been of central concern to national planners, economists and others. Legislation in Canada and the United States calls attention to the need to encourage the revitalization of rural areas [6, 7, 9, 10]. One result of concern at the national level with the social desirability of rural development has been a renewed interest in development strategy at the local level. The difficulty arises in translating national sentiments into terms that can provide a framework to guide the resource allocation process at the community level.

A wide variety of models have been proposed for dealing with the economic development and growth of subnational areas [1, 2, 4, 5, 8]. In this paper we suggest a programming framework which allows one to confront directly the issues involved in evaluating (as opposed to resolving) alternative strategies for rural community development. The model, presented in Section I, is designed to focus on the allocation of the community's limited resources among development activities, where the community's resources are specified within a qualitative, as well as a quantitative, context. Properties of the optimal solutions of the model are discussed in Section II. These properties are the basis for obtaining insights into the nature of community resource interrelationships of interest in evaluating rural development alternatives; these aspects also are developed in II. Concluding comments are given in Section III.

I. Development of the Model

In this section we suggest an analytical model which may be used as a tool in the rural community development planning process. The model allows one to focus on the use-pattern of the community's resources resulting from alternative patterns of economic development. Concern here is not with a model designed to generate "the" optimal development strategy for the community—an effort which may be futile given the problems of objectively defining appropriate weights for the community's criteria for development (income, employment, "quality of life", etc.). Instead, concern is with a model which brings together in an orderly fashion the multifarious, and

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often conflicting, criteria for development so that information may be generated concerning the trade-offs between criteria which may be useful in evaluating the community development process.

The following notation is used:

\( X_i \) is value added generated in the community from economic activity of type \( i \) (\( i = 1, \ldots, I \)).

\( L_j \) is acres (or square feet) of land in the community at site \( j \), currently available for particular activities, \( i \) (\( i = 1, \ldots, I \)).

\( C_j \) is annualized cost (including amortization, interest, and operating charges) associated with increasing the availability of type \( j \) land in the community via public investment in the bundle of "land-opening" infrastructure.

\( G_k \) is annualized cost (including amortization, interest, and operating charges) associated with increasing the community's type \( k \) social infrastructure (excluding debt incurred for increasing the availability of land).

\( D_k \) is a "dummy variable" which allows for deterioration of the quality of community services from type \( k \) infrastructure.

\( I_k \) is a parameter which measures capital infrastructure of type \( k \) (\( k = 1, \ldots, K \)) available in the community.

\( (K/Q)_{ij} \) is the capital-output ratio for activity \( i \) in site \( j \); "capital", as used here, refers to the activity's capital-type assets (including land) which are subject to taxes imposed by the community.

\( P_n, E_w \) are parameters which reflect the community's preferences regarding population characteristics (\( P_n, n = 1, \ldots, N \)) and environmental conditions (\( E_w, w = 1, \ldots, W \)).

\( T \) is federal and/or state transfer payments to the community.

Using this notation, consider the following optimization problem.

Maximize: 
\[
V = \sum_{i=1}^{I} X_i
\]  
subject to:

**LAND RESTRICTIONS**
\[
\sum_{i=1}^{I} \alpha_{ij} X_i \leq L_j + \eta_j C_j, \quad j = 1, \ldots, J
\]  

**CAPITAL RESTRICTIONS**
\[
\sum_{i=1}^{I} \beta_{ik} X_i \leq I_k + \gamma_k G_k + D_k, \quad k = 1, \ldots, K
\]  

**FISCAL RESTRICTIONS**
\[
\sum_{i=1}^{I} \sum_{j=1}^{J} \left[ (K/Q)_{ij} X_i \right] t_{ij} \geq \sum_{k=1}^{K} \left[ \sigma_k I_k + G_k \right] + \sum_{j=1}^{J} C_j - T
\]  

**POPULATION RESTRICTIONS**
\[
\sum_{i=1}^{I} \pi_{in} X_i \geq P_n, \quad n = 1, \ldots, N
\]
ENVIRONMENTAL RESTRICTIONS

\[ \sum_{i=1}^{I} \delta_{iw} X_i \leq E_w, \quad w = 1, \ldots, W \]  

(INITIAL CONDITIONS)

\[ X_i = \bar{X}, \quad i = 1, \ldots, I \]

In the system (1) - (7) above, (1) gives a posited criterion for community development: maximize value added generated in the community.\(^1\) The following restrictions, however, are imposed on the generation of value added to reflect the community's preferences vis-a-vis the quality and/or quantity of their resources. First, in equation (2), the \( \alpha_{it} X_i \)'s measure the pattern of land use which results from a development strategy. The quantity of land, \( j \), initially available in the community for specified activities, \( i \), is measured by \( L_i \), where \( L_i \) may reflect zoning categories or a more refined grouping of land uses which may better suit the circumstances in the community. In some applications it also may be desirable to allow the quantity of \( j \)-lands to increase if the community is willing to increase the supply of relevant land-related infrastructure—thus, the inclusion of the last terms in equation (2).

Second, referring to equations (3) and (3'), \( \beta_{ik} \) measures the use of type \( k \) infrastructure (schools, police, firemen, etc.) per unit of activity, \( i \). Total infrastructure use from economic activity in the community may not exceed the stock of infrastructure, \( I_k \), plus additions to that stock as measured by \( \gamma_k G_k \), where \( \gamma_k \) is the increase in type \( k \) infrastructure per dollar of public expenditure. The community, however, may be willing to allow a deterioration in the quality of their social infrastructure. The coefficient \( \beta_{ik} \) would normally reflect existing intensities of infrastructure use. Thus, with equality in (3), i.e., where public service \( k \) is provided at capacity, positive values of \( D_k \) imply an increased intensity of use of the area's infrastructure (e.g., more students per teacher, a greater population per fireman or policeman) and may reflect a decrease in the quality of public services. Equations (3) and (3') thus permit an evaluation of the impact of allowing such deterioration on the resulting pattern of community development.

Third, equation (4) imposes a fiscal constraint on the development process; \( t_j \) is the tax rate for activity \( i \)'s taxable assets in area \( j \), and \( \sigma_k \) is the operating cost (including, in some applications, debt retirement) for existing infrastructure \( I_k \). Equation (4) then requires that tax revenues be at least as great as the community's payment obligations, less any intergovernmental transfers.

Fourth, some communities may desire restrictions on population characteristics, e.g., population and/or employment levels, age distribution, average income levels, average education levels, etc. Such restrictions are permitted by equation (5), where \( \pi_{in} \) is the impact on labor characteristics \( n \), \( n = 1, \ldots, N \) per dollar of value added in activity \( i \).

Fifth, environmental preferences are specified by equation (6). Environmental effects (solid waste disposal requirements, air-water pollution, etc.) may not exceed limits \( E_w \), \( w = 1, \ldots, W \) defined by the community.

\(^1\) Initially we treat the criterion as total value added. Of course, other criteria, such as total sales, local value added, or employment, may be more useful in some applications.
One also can impose the *existing* pattern of economic activity on the optimization process (equation 7). In this case, $L_j$ in equation (2) is interpreted as the amount of type *j* land available, i.e., not already developed. Finally, while not included in (1) through (7), it also may be desirable to include the secondary impacts of growth in "primary" activities on selected "secondary" activities by including the following equation:

$$X_h \geq \Delta_{1h}X_i, \quad i, \ h = 1, \ldots, I, \ i \neq h$$

In (8), each unit of *i* induces $\Delta_{1h}$ units of activity *h*; $\Delta_{1h}$ is the "multiplier" effect of *i* on *h*. Thus choices among activities are made explicitly, as opposed to the mechanical, aggregate multipliers usually found in export-base models.

It is useful to call attention to some of the major shortcomings of the model. First, the model is "timeless" and permits only a comparative statics view of the community's development process. Second, impacts of development on land values and other pecuniary externalities are not considered. Moreover, the aesthetic impact of particular activities is not taken into account except to the extent that the *j* land categories eliminate or reduce this type of externality. Third, no differentiation is made between external (to the community) and internal supplies of labor which may be used by economic activities (see equation 5), and the labor supply is implicitly perfectly elastic at the (non-specified) existing wage. This argument applies equally well to capital. The model, then, is demand oriented in this regard.

Finally, but not exhausting a review of possible limitations, economic activities are viewed solely from the demand side—the "supply" of such activities is assumed to be perfectly elastic. The model does not "determine" whether or not type *i* activities will or will not locate in the study-community. If the resources are provided, the industry (or activity) is assumed to operate in the community. This shortcoming may be acceptable since a local analyst will define activities $X_i$ with some confidence in the feasibility of positive levels of such activities.

**II. Properties and Uses of the Model**

As this model is structured, the community affects development via policies (decision or control variables) for types of economic activity chosen ($X_i$), debt incurred for improving the quality of land (through investment in infrastructures, $C_1$), increasing other types of infrastructure ($G_k$), and allowing the quality of social infrastructure to deteriorate ($D_k$). Maximization of (1) through (7) may be viewed as that of maximizing the Lagrangian expression:

$$A = \sum_{i=1}^{I} X_i - \sum_{j=1}^{J} \lambda_j \left( \sum_{i=1}^{I} \alpha_{ij}X_i - L_j - \eta_jC_j \right)$$

$$- \sum_{k=1}^{K} \gamma_k \left( \sum_{i=1}^{I} \beta_{ik}X_i - I_k - \gamma_k G_k - D_k \right) - \sum_{k=1}^{K} \epsilon_k (D_k - D_k^*)$$

$$+ \Psi \left( \sum_{i=1}^{I} \sum_{j=1}^{J} [(K/Q)_{ij} X_k t_i] - \sum_{k=1}^{K} [\sigma_k I_k + G_k] \right)$$

Given the model's resource focus, our optimization problem may be stated as an intertemporal allocation problem along the lines suggested in, for example, Burt and Cummings [3].
The Lagrange multipliers $\lambda_j$, $\Gamma_k$, $\epsilon_k$, $\Psi$, $\theta_n$, $\phi_w$, and $\mu_i$ are associated with the restrictions given in equations (2) through (8), respectively, and may be given the following interpretations:

- $\lambda_j$ is the scarcity value of land $j$,
- $\Gamma_k$ is the scarcity value of type $k$ infrastructure,
- $\epsilon_k$ is the scarcity value of depreciation infrastructure's marginal contribution to growth (in the $X_i$'s),
- $\Psi$ is the imputed growth cost of the fiscal conditions; tax receipts must equal community expenditures,
- $\theta_n$ is the marginal scarcity value to the community of population characteristic $n$,
- $\phi_w$ is the marginal scarcity value of environment characteristic $w$,
- $\mu_i$ is the marginal cost to the community (via the opportunity cost of infrastructure consumed by $X_i$) of the existing level of $X_i$.

Assuming positive values for $X_i$, $C_j$, $G_k$, and $D_k$ in equilibrium, equations (10), (11), (12), and (13) are the relevant equilibrium conditions which result from our community development model.

$$\sum_{j=1}^{J} \alpha_{1j} \lambda_j + \sum_{k=1}^{K} \beta_{1k} \Gamma_k - \sum_{j=1}^{J} (\frac{K}{Q})_{1j} \Psi = \sum_{n=1}^{N} \pi_{1n} \theta_n + \sum_{w=1}^{W} \delta_{1w} \phi_w + \mu_i$$ (10)

$$\Psi = n_1 \lambda_j$$ (11)

$$\Psi = \gamma_k \Gamma_k$$ (12)

$$\Gamma = \epsilon_k$$ (13)

Equations (11) through (13) relate to the policy variables $C_j$, $G_k$, and $D_k$, respectively. Equation (11) implies that investment in $k$-type land-related infrastructure in zone $j$ ($C_j$) is carried to the point where the value of such investments (the scarcity value of land $j$, $\lambda_j$, times the increase of land $j$ from one unit of investment, $\eta_j$) just equals the imputed scarcity value of investment funds, $\Psi$. By (12), the scarcity value of investment funds, $\Psi$, also equals the scarcity value of social infrastructure, $\Gamma_k$, adjusted by the increase in social infrastructure which obtains from an increment in investment, $\eta_j$. The marginal scarcity value of infrastructure, $\Gamma_k$, must equal the marginal (growth) value of deterioration, $\epsilon_k$, by (13).

If the infrastructure and fiscal constraints (restrictions in equations 3 and 4) are effective, deterioration is allowed to the point $D_k = D_{k*}$, inasmuch as $D_k$ is a costless (in a direct sense) way of acquiring more type $k$

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3 For any restriction (2)-(8) which is not effective in the optimal solution, the associated multiplier has a zero value.
infrastructure. If, in the optimal solution, \( D_k < D^*_k \), infrastructure would not be scarce, \( e_k \) would be zero, as would be \( \Gamma_k \) and \( \Psi \).

Equation (10) relates to the community's choice of economic activities, \( X_i \), and has the following interpretation. Activity \( i \) is brought into the community until the marginal value of the activity's contribution to community development (\$1 in value added, in this case) equals the marginal imputed cost of the activity's consumption of the community's resources.

Planners willing to consider quantitative and qualitative changes in the resource base, as expressed symbolically in equations (3) through (6), can gain insights into the interrelationships of the development process. To illustrate, by permitting changes in the restrictions, the "opportunity cost" of progressively more stringent air or water standards, in terms of changes in the value of the chosen criterion function, can be measured. Similarly, any of the other restrictions can be varied to obtain an explicit expression of the "trade-off" between changes in the community's socio-economic resource restrictions and the resulting change in the level (or composition) of economic activity.

### III. Concluding Remarks

Concern at the national level with the broad issues associated with the social desirability of achieving a "sound balance" between urban and rural life by promoting the development and revitalization of rural areas creates a need for approaches at the micro level which are sufficiently comprehensive and flexible to encompass the economic and social concerns of rural communities weighing various development alternatives (including no development). The argument submitted in this paper is that many of the complex social and economic goals and concerns of communities when confronting development options can usefully be viewed as turning to the question of how the community's resource base, broadly defined, is to be used. With the problem viewed in this light, empirical analysis of many of the socio-economic interrelationships accompanying development can make contributions to the decision making process affecting rural localities. The theoretical framework presented here encourages planners to examine systematically the linkages among community economic and social objectives, and, in addition, trade-offs between conflicting criteria can be examined.

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4 The impact of varying the tax rate on the pattern of community development may be noted by observing that the marginal value of changes in \( t \) is given by \( \frac{\partial A}{\partial t} = (\Sigma X_i \Sigma K_j \Sigma Q_k) \Psi \), i.e., the marginal scarcity value of investment funds multiplied by the community's tax base associated with activity \( i \).
REFERENCES


