A Cost-Benefit Evaluation of Transportation Corridors

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The transportation corridor approach to planning transportation is a mixture of 3 basic ideas: buying land early, buying more land than is needed for initial transportation facilities, and buying more land than will be needed for transportation alone. The land is held in a lower level of use than would otherwise develop so that transportation costs are reduced and efficient land use promoted. The relevant costs for cost-benefit analysis are the economic costs of acquiring and holding land. The main benefits are savings in costs. Indirect and intangible costs and benefits can be expected because of the impact of transportation on land use. The nature of costs and benefits and possible methods for measurement are described in the paper. A benefit-cost model is then described by which the essential questions of how much land to buy, and when, can be evaluated. The maximum tangible net benefit from the corridor approach to transportation planning will be attained by buying land when the cost of delayed acquisition is rising more rapidly than the cost of early purchase. This simple relationship is the heart of the corridor concept.

•THE CORRIDOR CONCEPT has been espoused by individuals and groups in a variety of forms as early as 75 years ago (1, 2). However, there are several unifying elements in all these ideas that can be distilled to yield the concept. Two elements in particular run through the variants: (a) buying early (advance acquisition) and (b) buying more (more than short-run needs would dictate). These in turn imply a third element: (c) using the land for multiple purposes.

These 3 elements can be seen as important parts of the early antecedents of current notions about corridors. There are 3 distinct areas of highway planning where these ideas have appeared with some regularity in the past. The first is the city beautification movement of the 1930's. The second is the multimodal transportation route that combines roads and rapid transit on the same right-of-way. Finally, the present emphasis on scenic highways also illustrates the concept in another form.

The multiple elements of the corridor concept and the complex ramifications of specific corridor proposals have made it difficult to apply a general analytic framework to the evaluation of corridor proposals. The objective of this paper is to outline a general framework with which corridor proposals can be analyzed. The method suggested requires a standard application of cost-benefit analysis. In outlining an analytic framework, the paper draws attention to the lack of empirical data so essential for effective evaluation to be carried out.

THE NATURE OF TRANSPORTATION CORRIDORS COSTS

The economic uses to which land may be applied are numerous and often competing; this is particularly true in an urban or semiurban environment. Consequently, the use

Paper sponsored by Committee on Socio-Economic Aspects of Highways and presented at the 49th Annual Meeting.

of land in transportation corridors is associated not only with development costs but also with substantial initial acquisition costs to take land out of other productive uses.

Economic Costs

The real or economic cost of using any piece of land in a transportation corridor is the loss of goods or services incurred by not having that land available for other uses. That is what economists call the opportunity cost of land (3, p. 16). This cost may or may not be the same as the price that has to be paid to acquire the land.

Financial Costs

The financial cost is simply the monetary outlay that is necessary to obtain the right to use land. These costs are easiest to substantiate and are most frequently provided in descriptions of transportation projects (4).

Direct Costs

Direct costs are those incurred in the acquisition and holding of property in a transportation corridor. Either economic or financial costs may fall in this category.

Indirect Costs

Indirect costs arise as a consequence of property being held as a transportation corridor. The costs are not associated with the payments made for the corridor land but arise from phenomena that result in adjacent land.

Intangible Costs

Not all costs appropriate for the government to consider can be expressed in monetary terms. For example, noise and smoke pollution are real costs, but are not generally stated in dollar terms. These are termed intangible costs (5, pp. 58-62).

Tangible Costs

Any cost that is initially expressed or that can be reasonably translated into a monetary cost may be referred to as a tangible cost.

RELEVANT CORRIDOR COSTS

When any assessment is made, only those costs and benefits that are incremental to the decision should be taken into account as relevant for the decision. Although obvious, this rule is frequently violated and must be stated explicity (6, p. 161). In relation to the corridor concept, it implies that the relevant costs to be considered are those of buying earlier than might otherwise be the case and buying more land than might otherwise be the case. To determine these relevant costs, we recommend that the present value of total costs of acquiring a corridor be compared with the present value of total costs of acquiring transportation routes later. (Forecasting and other problems of benefit-cost analysis are implicit, as indicated earlier.)

Direct Costs

Acquisition Cost—The financial costs of buying or expropriating land and improvements are conceptually clear and in practice can be readily estimated. They will reflect not only the price paid but also associated professional costs for necessary appraisal and legal work. Additional costs, in the form of compensation to former occupants for displacement, are also likely to be incurred. Intuitively these costs may be expected to be closely related to the degree of urban development and, as a proxy measure, to population density. These expectations have been supported by analysis of right-of-way costs (4; 11, p. 110). In order to place these and any other costs on a similar time basis, all costs and benefits will be discounted to a present value (6, pp. 158-159). Mathematically the financial costs of right-of-way acquisition per mile may be expressed as

$$PW_{row_i} = \frac{\left[(PL + PI)_{row_{in}} + PP_{row_{in}} + PC_{row_{in}}\right]}{(1 + r)^n} f(x_i)$$

where

PW_{row_i} = present value of the cost of acquiring a unit of right-of-way for the i th mile;
PL = land value;
PI = value of improvements such as buildings;
$(PL + PI)_{row_{in}}$ = purchase price of right-of-way unit for the i th mile in year n;
$PP_{row_{in}}$ = professional costs associated with acquisition of right-of-way unit for i th mile in year n;
$PC_{row_{in}}$ = compensation costs associated with the acquisition of right-of-way unit for the i th mile in year n;
$1/(1 + r)^n$ = present worth factor at discount rate r for year n; and
$f(x_i)$ = a function expressing the relationship between right-of-way unit costs in a year and population density over the i th mile.

A right-of-way unit could be a measure of any appropriate size—for the example above, 100 ft wide by 1 mile long. Total acquisition cost for the corridor is obtained by summing all mile units of right-of-way.

The economic costs of right-of-way acquisition should measure the net present value of the goods or services that the land and improvements would otherwise have been used to produce. In a perfect market the price will reflect this return as measured by investors, so that it is often recommended that the economic cost be measured by the market value (3, p. 61). Because transportation routes generally have a significant effect on property values, however, a problem arises (1, p. 82; 8, pp. 144-180; 9; 10). The relevant economic value of the property is the value under an alternate use and, therefore, the value if no transportation corridor exists. Therefore, if values in the area have been affected by the expectation that a transportation corridor is going to exist, the price is likely to be in excess of the economic cost. This problem is clearly dependent on the extent to which the market has reflected the expectation of a transport route development. A means for avoiding this problem is in fact to buy early—a basic part of the corridor concept. In addition to the economic value of the land and improvements, the economic costs should include outlays for professional service and compensation payments for movement expenses.

Holding Costs—A significant cost associated with buying early is the holding cost. This cost is made up of 3 components: lost taxes, capital costs, and maintenance costs.

Lost taxes are not only a financial loss to government, but also a real economic cost. The wealth produced by land, currently or at a future time, must yield enough to cover not only the cost of other resources used but also profits and taxes. The taxes, therefore, are covered by a part of the wealth generated from the land under other uses. These taxes are not reflected positively in the price paid for the land, and so the taxes themselves may be used as a measure of this wealth.

The capital cost or interest foregone on substantial sums invested in corridor property could soon become substantial. If 8 percent were the appropriate opportunity cost of capital, the absolute value of interest foregone over a 9-year period would equal the original acquisition cost.

Maintenance costs will be incurred although the level will depend on the nature of the property and the use to which it is put.

Indirect Costs

Indirect costs are those induced in adjacent areas or in the community at large, as distinct from those confined to the acquisition and holding of right-of-way. These indirect costs are likely to be intangible.

The "Cost" of Government Intervention—The corridor concept implies a greater intervention of government within the property market. This cost could be one of the major obstacles that government might face when attempting to gain acceptance for the corridor concept. The political and legislative problems that are implicit will encourage the minimum of government interference or participation in the land market even though excess condemnation may seem desirable to assist financing or bring about more efficient land use.

Ecological Effects—Transportation corridor development is likely to have diverse ecological effects. The concept will allow the economic provision of more transport facilities than would otherwise be the case. However, wider bands of roadway and other rights-of-way will have more disrupting effects on drainage, local and microclimates, and, therefore, plant and animal life.

Land Speculation—It seems likely that the corridor concept could encourage land speculation. This might not only be regarded as a cost (vice?) itself but would be associated with economic costs. The effects of speculation can probably be minimized by modifying the basic corridor concept or by taking appropriate compatible action or by both. The corridor concept could be deliberately extended to encompass the acquisition of land for later resale. This would diminish the expected return from private speculation and would have the added advantage of providing financial means at very low economic cost. The sale of adjacent land later is a good method for "taxing the betterment" that results from the highway, i.e., transferring the windfall from private to public lands. The tax structure itself could be established to discourage speculation. Heavy reliance on the current market value of the land would likely achieve this. Because speculation arises out of uncertainty, information on the transportation plan (and associated land use plan if applicable) could be made available as early as possible. This would result in a greater stability of land price and, if the plan announced at the early date is the desirable one, a more efficient land use system.

METHODS FOR MONETIZING COSTS

The costs of right-of-way acquisition for highways generally range from about 5 percent of total cost in rural areas to over 55 percent in urban areas (11, p. 94). The relative level of acquisition cost can be expected to be low for transportation corridors because of early purchase; nevertheless the interest holding cost is directly related and sensitive to the initial cost. The ability to express or estimate costs in monetary terms is largely dependent on the frequency with which monetary transfers have been made in the past.

Direct Costs: Acquisition Costs

The problem of estimating financial acquisition costs is one with which highway departments are familiar. The usual basis is the appraisal of market value, to which should be added professional costs and compensation payments. This method gives a good measure of financial costs to be incurred in the short term.

Longer term estimates of acquisition cost, however, require that the expected nature and intensity of use be forecast before the market value can be estimated. Relating these characteristics to market value, as indicated by current patterns, needs to be placed within a standardized framework such as statistical analysis. Balkus and Srour (4) have indicated the reasonableness of regression analysis for relating costs to population density in the estimation of acquisition and construction costs for limited-access highways in the Tri-State region.

To estimate the economic costs of land acquisition requires a measure of the net present value of production foregone plus professional costs and compensation payments. It is reasonable to assume that the property market results in values reflecting the expected present value. However, the appropriate land use on which this estimate has to be based is that without the corridor. Two checks may be made to ensure that recent market transactions have not reflected the anticipated future development of the corridor. First, statistical comparison may be made of the recent property values in the area of the proposed corridor with those in the same area in the past and with those in

other areas of similar land use. Second, the plausibility of speculation concerning the corridor having affected values may be tested by finding out the views of residents and determining the interests of recent buyers of property. It also seems likely that some of the acquisition costs may not be expressable in monetary terms. For example, the social costs of family disruption would have to be dealt with as an intangible.

Direct Costs: Holding Costs

Lost Taxes—The estimate of taxes foregone requires a more explicit estimate of annual productivity without the corridor than is the case with purchase price. For the latter, market expectations and discounting establish the purchase price. However, the marketplace does not explicitly place a present value on taxes. The easiest and most reliable way to estimate the value of taxes foregone is to examine the returns from comparable land. Most likely expressing tax as a function of a forecast of population density would be the most reliable method for estimating future taxes in urban and semiurban areas.

Interest Charges—Considerable controversy surrounds the question of the appropriate cost of capital in relation to government projects. If funds have been raised for a particular project through the money market, then the appropriate cost of capital is known for financial evaluation. However, when funds are available from taxes, or when an economic rather than financial evaluation is being carried out, the appropriate cost of capital is more obscure. This cost is likely to be a critical one in transportation corridor economics, yet it is perhaps one of the most difficult problems in the appraisal of public projects (12, pp. 94-104; 6, pp. 139-141, 160-161). The difficulty in the selection of the appropriate cost of capital is that no financial market reflects the cost of money to the government by taking into due account taxes, risk, and inflation. This is critical to the corridor concept because after 10 years at 6 percent each dollar of acquisition cost would be raised to $1.79; at 10 percent, to $2.59; and at 12 percent, to $3.11. The alternative methods and issues associated with measuring the opportunity cost (economic cost) of capital cannot be adequately dealt with within the framework of this paper. The cost, however, should exceed the government's borrowing rate, and in Canada currently the appropriate cost of capital would be at least 10 percent.

Maintenance Costs—Maintenance costs, like purchase price, can be estimated on the basis of equivalent costs on government lands. The cost level to the government could be affected significantly by any decision related to interim use.

Indirect Costs

Indirect costs are far more difficult to express in monetary terms than are direct costs. The effects are difficult to identify and measure, and most of the effects are intangible in nature. No attempt is made here to set out methods for monetizing these costs.

SOME BENEFITS OF CORRIDOR ACQUISITION

For purposes of exposition and simplicity, the multipurpose element of corridors will be subsumed under the other 2 elements: buying early and buying more. Accordingly, this section sets out some of the benefits accruing to the corridor concept by a discussion of those benefits that can be related to buying early and those that can be related to buying more. Obviously, some benefits accrue to the total concept and are not amenable to this dichotomy. Such benefits will be treated under buying early because all of the benefits that accrue from buying early will accrue also to buying more and early. In addition, there will be some unique benefits that derive from buying more.

Some Benefits of Buying Early

Direct and Tangible—The first and most heralded benefit is the saving in acquisition costs that results from the early acquisition of rights-of-way. This benefit derives from 2 sources. First, the land itself is cheaper, being acquired before significant urbanization has taken place. With land prices rising as rapidly as they have been in the recent past, this is a very appealing aspect of the corridor concept. A related saving is

the reduced cost in acquiring structures and other improvements, notably utilities. A second distinct saving results from reduced relocation and demolition costs. Again this follows from the acquisition being made before significant activities locate on the land.

Direct and Intangible—Certainly one direct effect of corridors is more efficient routing that results from the more careful planning of the corridor, its location, and early acquisition. The corridor can take the most efficient route without disrupting major urban complexes. Also, because the land has been purchased well in advance of actual use, much more efficient staging can be realized and more modern technology employed.

Indirect and Tangible—We could not identify any easily measured indirect benefits.

Indirect and Intangible—The first benefit that comes to mind is the induced effect that highway corridors have on surrounding land values and uses. Advance corridor acquisition enables the planner to integrate more thoroughly transportation and land. Advance acquisition also can lead to more rational use of adjacent land, particularly if planning is also carried out and announced well in advance of actual construction. Thus, economies of scale can be achieved particularly at planned interchanges and route intersections. Compact and efficient packages of land can be assembled and shopping centers and other service facilities located at these important points, again with economies of scale.

Some Benefits of Buying More

In general terms buying more and buying early allows one to realize all of the benefits (both direct and indirect, tangible and intangible) listed but more so. Thus, if buying early represents a saving in acquisition costs, buying more allows greater savings. The same holds for savings in relocation costs, increased efficiency in routing and planning, and so on. There are benefits that accrue to buying more, and these are the subject of the following discussion.

Direct and Tangible—These benefits are listed in the previous section. We could not identify any direct and tangible benefits that derive exclusively from buying more.

Direct and Intangible—All direct and intangible benefits listed earlier should be included. However, there are other very significant benefits from buying more in addition to those listed previously. The lesser of these is ensuring adequate capacity in the future. Such capacity might not be forthcoming under usual procedures of buying for current needs because future legal and political barriers might prevent or delay future acquisition of adequate rights-of-way. Problems of land assembly and intergovernmental relations could easily prevent future expansion of transportation facilities when they are needed.

A more important and, as we see it, probably the most important feature of buying more and buying it early is the tremendous potential for closer coordination between land use and transportation planners. Here the dichotomy between direct and indirect benefits becomes quite artificial. Some benefits of environmental planning, such as better regional land use planning, are clearly indirect. Others, such as scenic highways, have both direct and indirect effects. Direct effects are those intangibles that directly impinge on the traveler who drives on such a road. However, much of the appreciation he derives is from vistas and elements well beyond the highway itself. Thus, he is experiencing an appreciation for the total environment that includes the road, its immediate landscaping and surroundings (the expanded right-of-way), and the environmental setting that stretches off in 3 dimensions all about him. Utilizing the corridor in this broadened context allows for an integration of all the previous conceptions of the corridor.

One final and very important aspect of buying more relates to the direct influence of such a policy on the land market. Speculation is known to follow construction of new highways into the rural fringes of urban areas. This speculation is particularly great near proposed interchanges. The existence of large quantities of excess land provides the planner with a very powerful tool. He always has the ability to dump the excess or threaten to dump it on the open market. Its greatest use is as a threat. Even once exercised, however, this power to dump land on the market can greatly influence the kind of development that takes place. Negative tools like zoning and building permits

have been only partially successful, and positive influence is of much greater importance, particularly when carried out through the market mechanism and its output prices.

METHODS FOR MONETIZING BENEFITS

No attempt is made here to set out methods for expressing intangible benefits in monetary terms. This is not to say that measurement of intangibles is an altogether impossible task. Undoubtedly, however, much of what is called intangible today will be measurable with relative ease in the future. The benefits set out here are direct and tangible. Passing mention is made of several indirect tangible benefits that will be measurable in the near future with the increased use of urban and regional simulation models. In the absence of such models, indirect benefits are largely immeasurable. The direct benefits that can be measured with some degree of accuracy are those dealing with savings in land acquisition costs, relocation costs, and construction costs. These benefits are given here in simple mathematical form. Indirect effects that are of interest are the impact of the corridor on surrounding land use and value and the possibility for economies of scale resulting from better planned roads, shopping centers, and new towns. Some general remarks will serve to set the approach that must be taken in the future if these important effects are to be included in the planners' calculations, but no estimation procedures are specified.

Savings in Acquisition Costs

The savings in acquisition costs will be

Savings = discounted future acquisition cost of property - [present acquisition cost + discounted holding costs]

Mathematically, this statement appears as

$$S_A = \sum_{m=1}^{M} \left[\frac{P^m_{row_{Nm}}}{(1+r)^{N_m}} - \left(P^m_{row} + \sum_{n=1}^{N_m} \frac{H^m_{cn}}{(1+r)^n} \right) \right]$$

where

S_A = savings;

$P^m_{row_{Nm}}$ = acquisition cost of the m th unit of right-of-way in year n;

P^m_{row} = present acquisition cost of the m th unit of right-of-way;

r = discount rate;

M = number of right-of-way units purchased;

H^m_{cn} = holding cost in year for the m th unit of right-of-way; and

N_m = number of years in the future that right-of-way parcel m will be acquired.

Several important questions are raised by this formulation. First, what value is attached to r, the discount rate? This is a critical problem in all cost-benefit studies and is avoided here (6). Another important variable that has been discussed elsewhere in this study is the holding cost. This too is taken as given.

The present purchase price is either given or relatively easy to ascertain by simple methods of appraisal. Therefore, we shall assume that it also is available for this calculation. Attention focuses, therefore, on estimating the future purchase price n years into the future. Because the corridor concept entails considerably longer range planning than is presently practiced, choosing n as 20 or 25 years seems reasonable. Forecasting for even 5 years is an extremely hazardous task. Extending the forecasting

horizon to 20 or 25 years borders on the theological and metaphysical. However, there are techniques for longer range forecasting that at least incorporate the variables that we think are important in price determination. Given that the user of such longer range forecasts fully realizes the gross inaccuracy that must typify any such prognostication, it is useful to at least set out some formats for hazarding guesses of future purchase prices.

The simplest way is to forecast some trend in prices based on past experience. Such a trend can easily be modified to take into account changes in density in the outlying area. This is exactly the technique used by Balkus and Srour (4). They relate acquisition costs to density and establish a good relationship between the two. Traditional methods of appraisal are also useful for providing a rough idea of probable future selling price. A good appraisal on these lines would draw heavily on the judgment and expert knowledge of the resident appraiser.

Notions about density are combined with the width of the right-of-way in the analysis of right-of-way costs by Meyer, Kain, and Wohl (11, pp. 210-211). Their formula for acquisition costs can easily be applied once estimates are provided of the width of the right-of-way and, more importantly, of the future density pattern of the area through which the corridor is to be constructed. This density pattern can be estimated, of course, by the use of existing simple trend and judgmental techniques. Simulation is a far better tool, however. Only through comprehensive models of urban development can a clear understanding of the urban region be derived. Such models are now little more than 6 years old, but progress has been rapid. Changes that have taken place are indicated in 2 papers by Lowry (13, 14), who designed the first simulation model in 1964. Since that time important theoretical questions have been faced, more powerful computers have been built, and more data have become available. Th modeling art is well on its way, and some definite modeling approaches appear to be evolving (15, pp. 363-412; 16; 17).

Savings in Relocation Costs

Relocation cost savings can be set out in an analogous way to savings in purchase price:

$$\text{Savings}_{\text{reloc}} = \text{discounted future relocation costs} - \text{present relocation costs}$$

In mathematical notation, we have

$$S_{\text{reloc}} = \sum_{m=1}^{M} \left[\frac{RC^{m}_{N_m}}{(1+r)^{N_m}} - RC^{m} \right]$$

where

S_{reloc} = savings in relocation costs resulting from buying the M parcels at the present instead of at future times N_m;
$RC^{m}_{N_m}$ = relocation costs of parcel m purchased at N_m;
RC^{m} = relocation costs of parcel m purchased at present;
m = parcel subscript; and
N_m = time subscript denoting probable future purchase time of parcel m.

Relocation cost estimates for the future are probably even harder to come by than cost estimates for land. Using judgment, however, we can get some idea of the future density and then relate the density to present experience on density and relocation costs. These costs can also be derived by the use of the more detailed and expensive technique of simulation.

Savings in Demolition Costs

The procedure for demolition cost savings is identical to those set out earlier:

$$\text{Savings}_{\text{demol}} = \text{discounted future demolition costs} - \text{present demolition costs}$$

Using the previous notation, we get

$$S_{demol} = \sum_{m=1}^{M} \left[\frac{DC^{m}_{N_m}}{(1+r)^{N_m}} - DC^{m} \right]$$

where

S_{demol} = savings in demolition costs resulting from purchase of M parcels at the present instead of at future times N_m;
$DC^{m}_{N_m}$ = demolition costs of parcel m purchased at time N_m;
DC^{m} = demolition costs of parcel m purchased at present;
m = parcel subscript; and
N_m = time subscript denoting probable future purchase time of parcel m.

Once again we have the problem of estimating demolition costs. Ways analogous to those set out previously surely will suffice. Thus, historical information on demolition costs per mile of right-of-way of a given type (urban, suburban, or rural) can be combined with judgment as to the expected character of the land in the future and its probable density of development. Of course, more elaborate and complete simulation techniques would be applicable as before.

The total direct benefit therefore is

$$S_{total} = S_{land} + S_{rcloc} + S_{demol}$$

For all intents and purposes, these will be the only measurable benefits.

A BENEFIT-COST MODEL FOR CORRIDORS

By the nature of the corridor concept, the calculation of benefits implies the benefit-cost model because the benefits are stated in terms of the savings accruing from buying more and buying it early. A comparison between early and later purchase is implied by this sort of benefit.

Although the corridor concept carries with it notions of net benefits, it does not imply how these net benefits are calculated. The net benefits have been calculated by discounting the various costs back to the present. These net benefits are really net present value calculations (NPV) (18). This is certainly to be counted as a strength of the corridor concept because the net present value method is by far the most widely accepted selection criterion.

All of these calculations, however, have ignored the question of how early one should buy and how much. These were taken as given for the net benefit calculations, along with other basics such as the route and accurate forecasts of costs. This question of how early is really the crucial one. The question of how much is much less difficult to answer. It can be answered by comparing alternate projects with different right-of-way widths. Changes in the quantity of land will affect the optimal timing of the purchase but will not affect the method of selecting the optimal time to buy.

Figure 1 shows the 2 relevant curves that are really the foundation for the previous analyses of costs and benefits. The less steeply sloped curve, A-H, represents early purchase cost plus aggregate holding costs: interest charges, taxes foregone, and maintenance costs. The more steeply sloped curve, A-P, represents the cost of the same

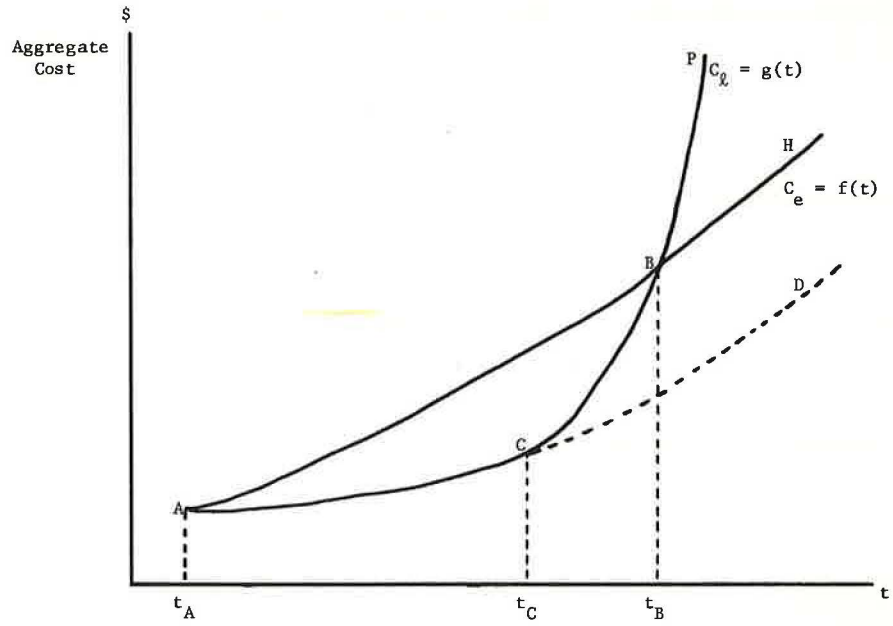

Figure 1. Acquisition, holding, and development costs.

land (quantity and location are the same as in the previous curve) over time and shows how property increases sharply in value after some urban encroachment has begun on the rural land market. The cost curves include demolition and development costs.

Assume that initial purchase is made at point A. After that, holding costs add to the initial cost of property to yield an upward sloping exponential growth curve of modest growth rates. In the meantime the land increases relatively slowly in value, as urbanization is still some time off in the future. Thus, initially, holding costs increase more rapidly than the cost of property acquisition, i.e., than a later purchase would have cost. Point B, on the other hand, demonstrates that if the land is going to be used after this time, t_B, then it does pay to purchase it as early as t_A. However, we still find that between t_A and t_B we have been paying holding costs that tend to reduce the net savings accruing from buying early. Clearly, buying at time t_A is a bit premature. Buying after t_B is too late; i.e., it costs more than if we did buy at t_A. The question is, then, What is the optimum time to buy so that holding costs can be minimized and net benefits maximized? We are really asking, How much in advance of urbanization should the purchase be made?

The solution to this problem is very straightforward and is a direct application of the methods of microeconomic theory (19, pp. 42-84). Form 2 functions corresponding to each of the 2 curves,

$$C_e = f \text{ (taxes, opportunity cost, maintenance costs, time)} \quad (1)$$

because all of these costs are given in advance—the only variable is time—and

$$C_e = f(t) \quad (1')$$

Thus, C_e, cost of buying early, is a function of time such that

$$\frac{dC_e}{dt} > 0$$

The cost of buying later, C_ℓ, is simply given by the property acquisition cost curve,

$$C_\ell = g(t) \tag{2}$$

such that

$$\frac{dC_\ell}{dt} > 0$$

What we want to do is maximize the difference, B, between C_e and C_ℓ:

$$\begin{aligned} B &= C_e - C_\ell \\ B &= f(t) - g(t) \end{aligned} \tag{3}$$

We maximize B by taking the first derivative of B with respect to t and setting it to zero and then solving:

$$\frac{dB}{dt} = \frac{dC_e}{dt} - \frac{dC_\ell}{dt} = 0$$

or

$$\frac{dC_e}{dt} = \frac{dC_\ell}{dt}$$

Thus, B is maximized, or minimized, where the slopes of the 2 curves are the same.

To ensure that this point is a maximum requires that the second derivative of the B with respect to t must be negative. This implies that

$$\frac{d^2B}{dt^2} = \frac{d^2C_e}{dt^2} - \frac{d^2C_\ell}{dt^2} > 0$$

For this expression to be negative, we must have

$$\frac{d^2C_\ell}{dt^2} > \frac{d^2C_e}{dt^2}$$

In words, this says that a maximum will be attained at that point if the acquisition cost curve is rising more rapidly (more steeply sloped) than the early-purchase cost curve. It is this simple relationship that is really at the heart of the corridor concept, and unless this relationship holds there is no financial sense in buying early. This does not mean of course that there are not a sufficient number of very significant intangible and indirect effects that may still make the corridor concept worthwhile as a tool for comprehensive planning. It is our feeling that this will be the case, because the concept is such a potentially powerful tool for planning urban environments.

FURTHER RESEARCH

Data Base

To test the economics of a transportation corridor requires that considerable data be available. For the effective and extensive implementation of the corridor concept, a data bank must be developed. It is very important that general explanations of property value be developed; population density appears to be the most significant variable. This information should be in such form that it can be combined readily with forecasts of population distribution and density so that critical times for land acquisition may be estimated. An inventory of studies into other cost components should also be established—for example, the level of taxes paid according to land use and land value and the level of maintenance costs for different types of public land.

Analytical Techniques

Research also needs to be carried out to improve the adequacy of analytical techniques. For example, in benefit-cost analysis the appropriate cost of capital is an unresolved issue. The evaluation of benefits, other than cost savings, also requires that far more be known about the relationship between transportation and land use and that methods be developed for forecasting the results of the interrelationship between them.

Methods for Minimizing Costs

An infinite number of design variables are possible in implementing the corridor concept. Some of the alternative approaches can be used to minimize the level of holding costs and make the corridor concept more attractive. Clearly, holding land in fee simple but without economic use is the most expensive way of holding land. Controlled economic uses of the land may be achieved in various ways—for example, by leasing or easements. Alternatively, the level of development on land to be acquired later or on land to be adjacent to the transportation routes could be controlled by zoning, official maps, and setbacks. If these methods are used in combination, acquisition and holding costs may be kept down while the benefits are enhanced.

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