ECONOMICS OF TRANSPORTATION CORRIDORS: AN EMPIRICAL EVALUATION

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This study is a continuation of work presented by the authors at the HRB 49th Annual Meeting in January 1969. The initial research focused on creating an analytical framework within which transportation corridors might be evaluated. The orientation of the present paper is empirical and, as such, focuses on the comparison of tangible benefits and costs. The discussion proceeds from a review of our earlier paper to the presentation of empirical results based on data from the Greater Vancouver area of British Columbia. This is one of the 3 major metropolitan areas in Canada with a current population of approximately 1.1 million people. Relevant literature is noted to provide the context for the present analysis. Areas for further research and application are noted and discussed. Finally, several tentative conclusions are drawn and discussed along with their implications for decision-making and policy.

•OUR EARLIER PAPER (1) was primarily concerned with defining transportation corridors. Having done this, we set out to delineate an economic framework for the evaluation of corridor projects. After reviewing existing literature on transportation corridors, we identified 3 elements that differentiate and, therefore, serve to define transportation corridors from the standard right-of-way. These elements are buying early (advance acquisition of the right-of-way); buying more (more than short-run needs dictate); and making multipurpose use of the land.

The economic framework that evolved was that of cost-benefit analysis. We, thus, set about to define the various kinds of costs encountered in such an analysis. These costs include economic or opportunity costs; financial costs or monetary outlays; direct costs, which are incurred in acquiring and holding land; indirect costs, which are induced in surrounding lands; tangible costs, which are easily measured in monetary terms; and intangible costs, which are not directly measured in monetary terms, i.e., equality of environment and noise. These costs provided a basis for analyzing the specific costs involved in acquiring more land than is needed immediately (i.e., corridors).

There were 2 primary sets of costs involved: acquisition costs and holding costs. Each in turn was subjected to analysis. The benefits were treated in an entirely analogous manner.

The substance of the argument, and the conclusions, can easily be illustrated by using the curves shown in Figure 1. In the future there are 2 curves. The curve C_e represents the cumulative costs of buying the land at time t_A and holding it and, thus, incurring holding costs each year. The second and more curvilinear function, C_1, represents the cost of buying at some later date. This curve illustrates the great appreciation of rural fringe land as it is brought into urban uses, roughly near the point C. This curve depicts the progress of land values over time and represents the actual purchase price of property at any point of time.

Figure 1 shows that it is not always economically wise to purchase land in advance of need. This follows because the early purchase plus holding cost curve is above the late purchase curve at all points to the left of B. To the right of B, land values accelerate to such an extent that early purchase plus holding represents an economic saving.

Sponsored by Committee on Social, Economic and Environmental Factors of Transportation and presented at the 50th Annual Meeting.

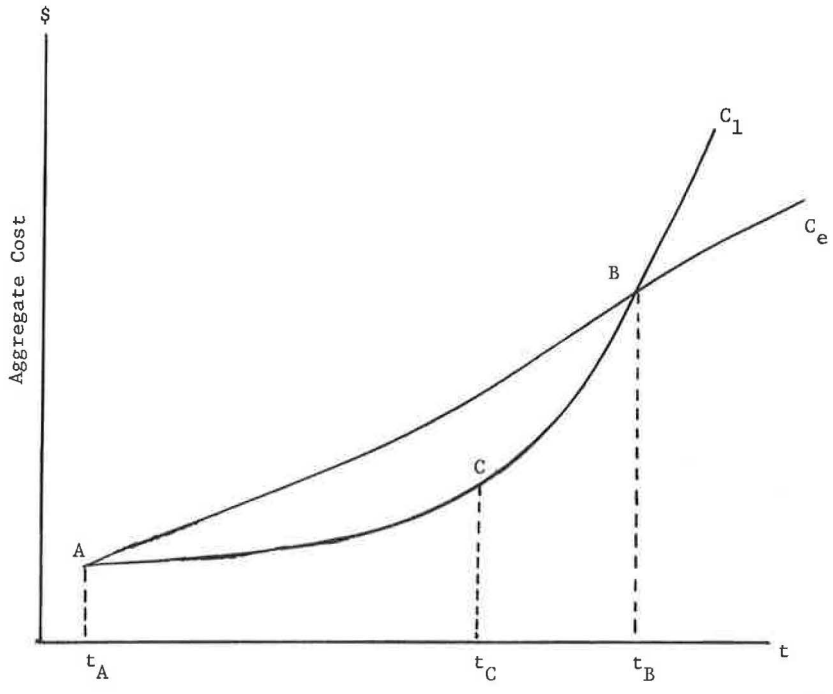

Figure 1. Acquisition, holding, and development costs.

Doubtless this situation is in most people's minds when they state that early purchase is a method of saving on acquisition costs. The more usual situation, where a corridor is planned to stretch out into some as yet undeveloped suburb, is represented by the acquisition points to the left of B.

By usual methods of microeconomic analysis, it can be readily shown that the optimum time to buy is where the slopes of the early and late purchase curves are parallel and the late purchase curve is rising more rapidly for successive points to the right, t_c. Point C is such a point and represents the maximum saving possible from buying early and the maximum vertical distance between the 2 curves. A straightforward proof of this proposition concludes our original argument.

MEASURING THE IMPACT OF TRANSPORTATION CORRIDORS

It is our intention in this paper to compare estimates of early and late purchase curves shown in Figure 1. In this way we hope, first, to demonstrate that the corridor concept need not necessarily lead to cost savings and, second, to provide evidence of the optimum approximate timing for the purchase of a given right-of-way in southwestern British Columbia.

The framework necessary for the study of land value to achieve these goals differs significantly from that taken in the highway impact literature. Land value has been of major concern to highway engineers and planners for many years. However, none of the land value studies that have been reviewed by the authors to date provides direct assistance in answering the question, How far in advance of urbanization should land be purchased for a right-of-way? The studies in the literature relating to land value reflect generally the concern with the cost of particular facilities or the benefits derived from them and report these to improve the input information for subsequent specific programs.

A major concern of studies employing the before-and-after concept has been to measure the change in land values attributable to highways (2, 3, 4, 5, 6, 7, 8, 9). These

studies have examined the change in the value of land in impact and control areas over a period when highway construction was undertaken. The studies have improved our understanding of highway impact and have improved our ability to evaluate the net effects of proposed highway programs. However, the studies of the time series data have been oriented specifically to impact measurement and even within this framework have given little attention to the "development time phasing" (10).

Another group of studies relates to land acquisition (11, 12, 13). The reports are very much concerned with the actual process of land acquisition and deal with legal issues that may affect the timing of acquisition and the amount of land that may be acquired.

There is a notable dearth of studies on urban land value trends (14). Those that have been carried out are frequently comparative studies. These are not concerned with the process of the land value increase. An exception to this is provided by 2 studies on land value trends commissioned by the U. S. Department of Housing and Urban Development (15).

The latter studies reflect the increased interest in land values in the late 1960's. Mounting costs of right-of-way acquisition and the resurgence of the corridor concept have contributed to this interest, exemplified by the 1966 Federal-Aid Highway Act. Under the Act, the Secretary of Commerce was directed to undertake a study of the advance acquisition of highway right-of-way for federal-aid highways. Consequently, it has been recommended that federal aid be provided to the states to acquire right-of-way 2 to 7 years ahead of highway construction (16). This limitation is entirely consistent with a rule developed by Drachman (17), with the then-prevailing interest rate of 7½ percent, that land must double every 6 years in value to be a worthwhile investment. This implies a growth rate of 12 percent. The legal problems for states to take full advantage of advance acquisition have also been recognized. However, it seems that no systematic studies have been published to assist agencies in deciding how much in advance of construction acquisition should take place. This paper is intended to make some contribution to the resolution of that problem.

FINDINGS AND SOME TENTATIVE CONCLUSIONS

The main study area that was chosen for our sample was the municipality of Richmond. Richmond is immediately south of the city of Vancouver. Because of its proximity to Vancouver and its semirural nature at the beginning of the study period in 1959, it was felt that Richmond provided the best laboratory to test the corridor concept.

Testing the Economics of Corridors

The economics of the corridor concept are extremely difficult to test. This derives from the interrelationship between property values and transportation improvements and the problems associated with forecasting the path of property values. In general, forecasting methodologies have not yet successfully handled price prediction. Without forecasts of prices of real property, it is not possible to estimate the late purchase curve shown in Figure 1 (i.e., lower curve).

We began, therefore, by acknowledging that such difficulties exist and decided instead to look at the economics of the corridor concept in retrospect and within an area of rapid urbanization influenced by a transportation improvement. The particular improvement in question is the freeway that begins at the U. S. border and proceeds north to the city of Vancouver, bisecting Richmond.

That Richmond is a rapidly growing area can be seen from the population information given in Table 1. Richmond's population growth is contrasted with the metropolitan figures to put it in proper regional perspective. All figures refer to June 1 of the relevant year.

Having decided on the study area, we next set out to collect data on the value of real property (land and improvements). The assessed value of some 200 properties was gathered from the assessor's office for the period 1958 to 1970. The year 1958 was chosen as a starting point, this being the earliest date from which a consistent assessment method was employed. A price index was constructed for land, improvements, and land plus improvements and is given in Table 2 and shown in Figure 2. A regression line against time was then fitted to the data on total real property values and appears

TABLE 1

POPULATION OF RICHMOND AND METROPOLITAN AREA

Year	Richmond		Metropolitan Area	
	Number	Percent More Than Previous Period	Number	Percent Growth
1951	19,186	85.01[a]	562,048	42.44[a]
1956	29,578	35.40	665,110	18.34
1961	43,323	66.77	790,259	18.82
1966	50,460	16.47	892,384	12.92
1969[b]	58,800	16.53	992,600	11.23

Source: Censuses of Canada and Greater Vancouver Regional District.

[a]A 10-year change between 1941 and 1951.
[b]Estimated.

as Eq. 1. That regression is also shown in Figure 2. The average annual growth rate for the regression (given by the exponent in Eq. 1) was 5.23 percent. At this rate an average property doubled in value every 13 years approximately.

$$V_p(T) = 0.0717e^{(0.0523T)}_{(0.0124)}, \text{ significant at 0.005 percent level} \quad (1)$$

$$R^2 = 0.6181, F(1, 11) = 17.8061, \text{ significant at 0.005 percent level}$$

where

T = time (1958, ..., 1970);
V_p = value of real property; and
e = natural logarithm base.

This average value relationship is of little help, however, in testing the whole corridor concept. The test we devised consists of two parts, each of which examines one of the two principle components of the corridor concept. Our numeraire is the value of real property because this reflects the cost of acquisition more closely than land values.

The two components are (a) buying more land than is immediately needed for the proposed improvements and (b) buying it well in advance of need. We turn to the case of excess acquisition first.

To examine this component, we looked at the properties in our sample that were less than 0.1 mile from the freeway. Such properties would fall within any expanded right-of-way. Our feeling was that this land also would have appreciated as a result of the highway and, if anything, would overstate the savings because the properties should be more expensive after the construction of the route. Thus, if the purchase of even this appreciated property did not pay, then surely it does not pay to purchase excess quantities of raw rural land. The regression equation expressing the relationship between time and property values for properties within 0.1 mile of the freeway is as follows:

$$V_p(T) = 0.0824e^{(0.0285T)}_{(0.0155)}, \text{ significant at 0.05 percent level} \quad (2)$$

$$R^2 = 0.2340, F(1, 11) = 3.3608, \text{ significant at 0.10 percent level}$$

where T, V_p, and e are defined as in Eq. 1.

TABLE 2

DEFLATED PRICE INDEXES OF REAL PROPERTY FOR ALL LAND USES

Year	Land	Improvements	Aggregate	Predicted by Regression
1970[a]	3.53	2.84	3.10	2.13
1969	2.71	1.24	1.70	2.02
1968	2.30	1.27	1.59	1.91
1967	2.35	1.24	1.59	1.82
1966	2.34	1.15	1.52	1.72
1965	2.42	1.18	1.57	1.64
1964	2.37	1.26	1.63	1.55
1963	2.32	1.27	1.60	1.47
1962	2.41	1.34	1.67	1.40
1961	1.21	1.34	1.31	1.33
1960	1.28	1.40	1.39	1.26
1959	1.22	1.16	1.18	1.19
1958	1.01	1.01	1.01	1.13

[a]The completion of several large developments accounts for this jump in the value of land and improvements.

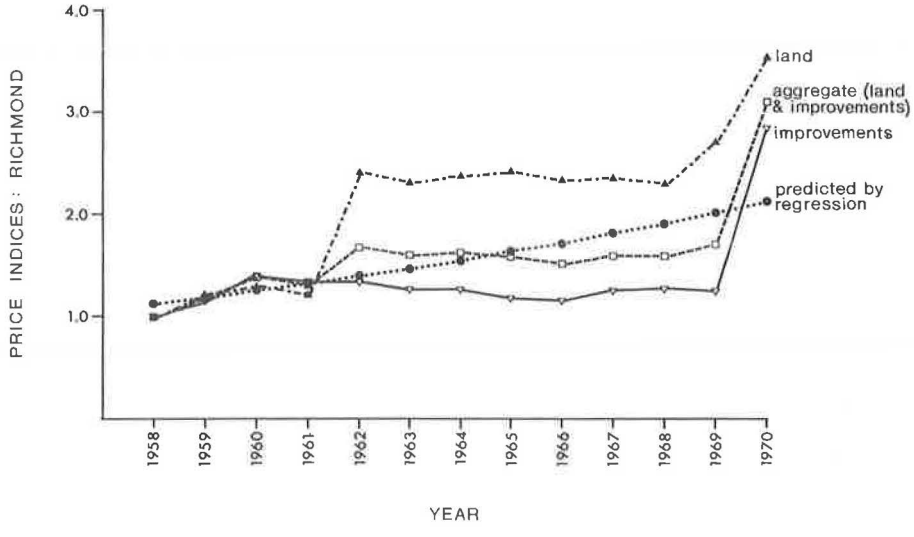

Figure 2. Actual versus predicted property values from 1958 to 1970.

The equation is significant at the 0.10 percent level and shows that since 1958 properties have been increasing at the average annual rate of 2.85 percent net of inflation (using the Consumer Price Index as a deflator). (The result of a lower rate of increase close to the freeway than in Richmond in total is unexpected. It results from the development of major complexes at grade street intersections removed from the freeway.) Thus, had the property been acquired in 1958 when the original right-of-way was purchased, the highway department would have saved 2.85 percent annually on purchasing the excess property. However, we must compare this with the opportunity cost of purchasing that property. Eckstein and others (18, 19) have estimated social opportunity costs from 6 to 10 percent. We chose a mean value of 8 percent. This exceeds the price appreciation savings. Taking the opportunity cost as the only cost, we find that there does not appear to be any economic advantage in buying more land than is currently needed. Such excess purchases would lead to an increasing economic loss because the annual 5+ percent loss is compounded.

Lacking evidence on possible annual revenues from property ownership, we have chosen to ignore lost taxes and maintenance costs. If the revenue exceeds the latter, we are understating the attractiveness of early purchase. However, a priori, we believe that the difference between the costs and revenue will be negligible and will not alter our conclusions. This assumption could be particularly sensitive to the value of rental income that could be earned from the corridor land while it is held in a low level use. Future research should test the assumption and should be a priority item in further inquiries into the economics of the corridor concept.

Looking now at the case of buying early, we return to the overall changes in property values in Richmond as a whole (Eq. 1). The rate of appreciation did not warrant advance acquisition, given our social cost of capital of 8 percent. We can tentatively conclude that early purchase is not economically justified for the case of suburban-semirural properties such as those in Richmond in general. It appears that the early purchase curve lies above the late purchase curve at all points, implying that property acquisition should proceed only as land is required.

Results for Burnaby to the east of Vancouver are similar. The fitted regression analogous to Eq. 1 is

$$V_p = 0.4842e^{\underset{(0.0097)}{0.0725T}},$$ significant at the 0.001 percent level

$R^2 = 0.7981$, $F(1, 14) = 55.3393$, significant at the 0.001 percent level

Here the growth rate is equal to 7.25 percent, which though higher than that for Richmond is still below our 8.00 percent target cost of capital.

Tentative Conclusions

We must tentatively conclude on the basis of these results that neither component of the corridor concept is economically viable in the case examined in this paper. This is not to say that the corridor concept should immediately be abandoned. The increased flexibility resulting from multiple use of corridors (which can only derive from excess acquisition) may well warrant incurring the higher economic costs. The other intangible benefits noted in our earlier paper, specifically more efficient integration of land use and transportation planning, may well provide the needed justification as well. All that we are saying here is that the apparent direct economic benefits do not seem to be present.

Before this section is concluded, it is well to ask how reliable are our data and therefore our results. The use of assessed values can immediately be called into question. A simple correlation between assessed values and actual sales for our sample yielded a coefficient of +0.823, which is significant at greater than the 0.001 percent level. Thus, these 2 sets of values are closely related.

Given that assessed values are realistic and usable, we can now question the reliability of the regression equations. In each of the equations, the relevant F-statistic for the regression line and the t-statistic for the exponent and the constant terms are significant at least at the 0.10 percent level. This means that they are significant results in a purely statistical sense and, therefore, worthy of bearing strong implications. In the following section we examine the generality of the results.

CONCLUSIONS AND FURTHER RESEARCH

The area selected for a practical test of the corridor concept is typical of a zone in which property acquisition for a corridor might take place. Richmond is a part of a rapidly growing metropolitan area. The municipality enjoys good access to the CBD and satellite commercial cores, and its population is increasing rapidly.

Two characteristics of the area are likely to be particularly favorable to rapid increases in values. First, a freeway was completed through the area in 1959. This accelerated the process of ripening for development. Although the freeway accelerated the ripening process, it did not immediately lead to development, a phenomenon noted in other studies of freeway impact in the rural-urban fringe (9, 20). Second, a significant amount of land is undeveloped, and it is land in this state that normally shows the greatest percentage appreciation in value (6, 10).

However, our data show that even the properties closest to the freeway only increased at a compound annual rate of 2.85 percent net of inflation. Properties in Richmond as a whole only increased at a compound annual rate of 5.23 percent net of inflation. While the data have the usual problems characteristic of land and property value samples, the statistical reliability of the data is very good.

If it is supposed that holding costs are only 8 percent per annum, the results show that the increase of value for suburban properties is not sufficiently great to make advance acquisition attractive. The cost savings possible from buying very wide corridors in advance of expansion requirements also appear to be very limited. These results are consistent with the evidence available in other studies that have examined property values over time.

The Bureau of Public Roads reviewed the results of more than 100 economic impact studies completed through 1961 (21). Although the aggregate change in value over a number of years appears substantial, this is the results of compounding values over several years. The review shows that even in highway impact zones the average annual rate of increase has been less than 10 percent (21, pp. 24-36). A study of northeast Philadelphia has shown a higher rate of increase over a 17-year period, 14.5 percent per annum in the case of residential land (15). There are, however,

difficulties in interpreting the results of this study because it is unclear whether data are in current or constant dollars. These increases, too, were accounted for by improved assessibility as well as general forces of increased urbanization. A recent study of West Vancouver during a period of very rapid urbanization (1945-67) has shown that the average annual increase in the value of undeveloped land was 9.24 percent (22). How well any of these studies reflects aggregate land values over urban bands is debatable because of sampling and valuation problems. In particular, Horwood has noted that the changes in value identified through particular sales cannot be attributed to the entire band of land (10, p. 20). The sales, therefore, overstate the real economic change that has taken place.

These studies all report average rates of increase in excess of those recorded in Richmond. It may be questioned, therefore, whether the experience in Richmond is typical of other rural-urban fringe areas. We think it is. The differences between our estimates and those of the other studies can largely be accounted for by our using real property values and not simply land values. When land values are substituted for real property values, for all the properties in our Richmond sample, we get a regression equation of

$$V_L = 0.0740e^{\underset{(0.0141)}{0.0872T}}$$

$$R^2 = 0.7767,\ F(1, 11) = 38.3094$$

which implies a growth rate of 8.72 percent per annum and is significant at the 0.001 percent level.

The difference in the significance and coefficient of determination, r^2, between this land value equation and that for real property in Eq. 1 can be accounted for by the variability of the assessment of improvements. The following data on the value of building permits issued in Richmond (including demolitions) give an idea of the variability of improvements in Richmond:

Year	Millions of Dollars
1958	18.992
1959	16.517
1960	9.462
1961	11.708
1962	5.499
1963	8.973
1964	14.908
1965	29.023
1966	13.615
1967	16.478
1968	36.828
1969	24.168
1970 (first half)	16.525

To conclude that the rate of increase in suburban property values is modest is a surprising conclusion at first sight. We are accustomed to reading of substantial changes during a number of years and certain cases of spectacular increases during a very short period. However, in reality, the effect of urbanization is gradual. Proportional changes in the radius of the city result in geometric increases in the supply of land (23). It takes a considerable time, therefore, for a zone to experience an acceleration in the rate at which the land values are increasing as urbanization approaches. The creeping process of urbanization consumes land lot by lot and results in gradual changes in the growth rate of wide bands.

To step out several miles from the suburbs to acquire land for transportation corridors is not warranted on the basis of an analysis of tangible acquisition costs. Even

as urbanization proceeds, the high level of holding costs demands that the rate of increase is in excess of 10 percent per annum before advance acquisition is warranted.

The high rate of appreciation necessary for an entrepreneur to make a profit by speculating in land was observed by Drachman (17). It should be noted that Drachman assumed an interest rate of 7½ percent and an inflation rate of 4 percent. Current financial costs would run 2 percent more than each figure boosting Drachman's carrying charges to nearly 18 percent, which implies a doubling of land value every 4 years instead of the previous 6 years. It should be noted that Drachman is concerned (as are others who talk of speculation) with the appreciation of raw land. The question of speculation (and urban sprawl) is not posed in terms of real property appreciation (i.e., land plus improvements). This follows because land alone is cheaper, provides a lower base on which appreciation can accrue, and is easier to speculate in because of its lower price. Finally, raw land is more liquid because it is not constrained in use. Our results point this out; raw land appreciates much more rapidly than does real property (8.76 percent versus 5.23 percent). The lack of liquidity depresses real property appreciation and thus makes the economics of corridors even more unattractive.

This conclusion obviously reduces the apparent attractiveness of the corridor concept; it does not negate it, however. Substantial intangible benefits have been recognized to stem from the concept. Advance acquisition reduces the social and economic disruptions inherent in removing a corridor of land from suburban uses. More positively, advance acquisition can be associated with an integrated planning of transportation and land use. Indeed, it seems apparent that the main merit of the corridor concept must be its potential as a planning tool. This suggests that land use controls within the corridor and adjacent to it are of much more importance than actual corridor acquisition. Too heavy an emphasis on cost saving may detract from its strengths.

The limited cost saving available from the corridor concept has been made evident. However, time series studies of land values in other rural-urban fringe regions are desirable to substantiate the generality of the conclusion. Studies should also be conducted to learn more about the relationship between population density and changing land value in the rural-urban fringe. This information would allow the acquisition of land for corridors to be planned and timed within the overall framework of urban development.

Finally, cross-sectional comparative studies of this type should be focused on property value and density gradient relationships for metropolitan areas of different sizes. By contrasting these relationships for different sized areas, the generality of the corridor concept could be ascertained. It may very well be that the concept is only relevant for metropolitan regions of certain sizes.

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