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Title of the paper SOME ECONOMIC ASPECTS OF THE REHABILITATION OF BUILDINGS

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Key words rehabilitation of buildings, building economics, Canada

Summary

This paper describes the importance and economic rationale of building rehabilitation, with special reference to the Canadian situation. Through a review of various economic evaluation techniques, an attempt is made to answer basic questions such as why rehabilitation instead of rebuilding, when to rehabilitate, and how much to invest. The paper concludes that in some situations the application of economic techniques may not provide conclusive evidence for or against rehabilitation, and makes an appeal for more studies to determine the effectiveness of economic factors in actual rehabilitation-related decisions.

Titre du texte QUELQUES ASPECTS D'ECONOMIQUES DE LA REHABILITATION DU BÂTIMENT

Auteur A.S. Rakhra

Organisation/Entreprise Division des recherches en bâtiment, Conseil national de recherches Canada

Mots-clés réhabilitation en bâtiment, économie du bâtiment, Canada

Sommaire

L'étude précise l'importance et la raison d'être économique de la réhabilitation, plus particulièrement en regard de l'économie canadienne. Par le biais d'une étude de diverses techniques d'évaluation économique, l'auteur s'efforce de répondre à certaines questions fondamentales, soit par exemple pourquoi réhabiliter plutôt que reconstruire, quand réhabiliter, combien y investir, etc. Il en vient à la conclusion que dans certains cas, l'application de techniques économiques peut ne pas offrir de preuve concluante pour ou contre la réhabilitation, et il suggère la réalisation de nouvelles études permettant d'établir les effets des facteurs économiques sur les véritables décisions en matière de réhabilitation.

SOME ECONOMIC ASPECTS OF THE REHABILITATION OF BUILDINGS

A.S. Rakhra, Canada

INTRODUCTION

A number of studies have examined the question of rehabilitating a building versus demolishing and rebuilding. Most of these studies have dealt with the normative aspects of the problem, i.e., how to choose rehabilitation over rebuilding, or vice versa. They have not emphasized the positive aspects, such as the reasons for undertaking the task of rehabilitation, the economic rationale behind the decision, or the amount of money that should be spent. Whenever answers to these questions were attempted, the techniques used were not satisfactory.

A topic as important as rehabilitation deserves more economic analysis than it has received.* The purpose of this paper is to review the existing literature on the economics of rehabilitation and to suggest an economic framework that can answer the above-raised questions. The importance and economic rationale of rehabilitation is described, with special reference to the Canadian economy.

DEFINITION OF REHABILITATION

Rehabilitation means different things to different people. Gordon Bagby wrote:

> "To a homeowner, rehabilitation encompasses everything from repairing the roof to changing a light bulb. To a contractor, it is the gutting and reconstruction of a home's interior. To an apartment owner, it is any improvement which allows him to increase the rent he receives. And to an economist, it is any reinvestment designed to forestall the capital depreciation of a structure...." (2).

For purposes of this paper, rehabilitation** is defined as a building activity that extends an existing building's economic life, without disturbing its

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* The importance of rehabilitation can be gauged by the resources being devoted to it and related activities all over the world. It is predicted that in the United States about $30 billion will be spent on retrofitting existing non-residential buildings alone for energy conservation purposes in 1985, up from $8.6 billion in 1980 (1).

**There are several rehabilitation-related terms currently used loosely and interchangeably, e.g., renovation, restoration, retrofitting, remodelling, etc. A distinction between rehabilitation and renovation activities may be in order here. Rehabilitation does not involve a change of use while renovation usually involves a change in use or capacity or occupancy. For definitions of these and other related concepts, see (3).

original features or use. It may require change of tenancy for its economic viability. It may also require upgrading (not necessarily to its previous or original state), remodelling, retrofitting (e.g., extra insulation) and some repairs.

Theoretically, it may be possible to define and differentiate between these terms, but statistically it is difficult to do so because they are interrelated. For example, a rehabilitation job may involve installing extra insulation or replacing a roof, or tearing down a wall to expand the living area.

Statistics Canada, a federal agency responsible for collecting and disseminating data on the Canadian economy, divides construction activity into two components: new construction and repairs. New construction is defined as the value of work performed on new structures plus the value of work performed on major alterations and conversions. Repair construction consists of minor renovations and alterations made to maintain the operating efficiency of existing structures.

From this classification, it is difficult to know how much of the repairs component of construction expenditure is rehabilitation, renovation or retrofitting. It is equally difficult to know how much of the new construction expenditure really falls into the category of renovation or rehabilitation. It is also not clear what constitutes major or minor renovations, conversions, additions, etc.

WHY REHABILITATION?

Several economic arguments have been offered to justify rehabilitation activity. The most noteworthy are described below.

Cash Flow and Affordability Argument

It is claimed by some that existing buildings can be rehabilitated quickly and cheaply.* It is believed that rehabilitated buildings cost 50% less than new ones with the same design and floor area. In Canada, new house prices went up 200% between 1971 and 1980, while the cost of operating and maintaining existing buildings rose 169%. Rising mortgage rates and new house prices combined to raise capital costs 418% during the same period, thus reducing affordability.

Energy and Other Scarce Resources Saving Argument

Materials used in buildings embody energy. It has been estimated that processing, manufacturing, transporting and putting in place construction material for new buildings account for 5-8% of total Canadian energy consumption

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*It has been proven, however, that in some cases rehabilitation is more expensive than new construction or rebuilding (4).

and that conserving even 1% of that energy represents a saving of millions of dollars. Statistics Canada reported that between 1971 and 1981, dwelling units valued at about $3.5 billion were destroyed. The fact that some of them were perhaps beyond repair indicates that their owners had failed to rehabilitate them.

An American study (5) indicates that new buildings require up to five times more energy for construction and operation over an expected lifespan than do rehabilitated buildings. This energy use disparity depends, of course, on the type and extended life of the rehabilitated building, how it was erected, and how it will be renovated.

Also, when comparing energy consumption per dollar of new construction versus that of rehabilitation, the balance shifts to rehabilitation. New construction, for example, required 98,000 Btu per dollar of activity in 1967, which was 32% more than for one dollar of activity in maintenance and repair (6).

Employment and Income Creation Argument

A recent study (7) in Ontario indicates that, for a given amount of money, residential rehabilitation generates more total employment and income effects (consisting of direct, indirect and induced effects) than does new construction. Furthermore, a large percentage of these effects, especially employment effects, are felt in the construction industry itself.

Demographic Argument

Population distribution is changing quickly both in Europe and North America. In Canada, for example, it is estimated that the 25-34 age group's share of the overall population will decline from 17% in 1981 to 13.2% in 2001, while that of the 65-and-over group will increase from 9.4% to 11.2%. This shift will have important implications for the type of housing required and hence for rehabilitation activity (8).

REHABILITATION ACTIVITY IN CANADA

There are no reliable data collected to indicate the actual level of rehabilitation activity in Canada. Part of the problem is due to the lack of agreement on the definition of rehabilitation. It is also due to the fact that the people involved in rehabilitation in the past did not keep records of expenditures.

The table below provides a rough idea about the extent of rehabilitation activity in Canada's housing sector. It may be noted that not all the expenditures under column 4 represent rehabilitation; a large part (about 55%) merely constitutes minor repairs. Columns 6 and 7 show that between 1977 and 1982, repairs and renovation activities, both as a percentage of total housing expenditures, rose from 15.7% to 21.8% and from 28.9% to 37.8% respectively. Conversions and alterations as a percentage of total renovation rose from 13.2% to 16.0%. However, expenditures on conversions fell significantly between 1981 and 1982 and those on alterations rose marginally. This was due to a surge in new housing starts in 1981. They rose again in 1982 when new construction activities slackened. This means that rehabilitation activity is still residual to some extent -- an activity that compensates for the loss of new construction activity.

VALUE OF HOUSING RENOVATION ACTIVITY (REPAIRS, IMPROVEMENTS, CONVERSIONS) AS A PERCENTAGE OF RESIDENTIAL CONSTRUCTION, CANADA 1977-1981 ($000's)

Year	Repairs	Alterations and Improvements	Conversions	Total Renovations	Total Housing Expenditures Including New and Repairs	Repairs as % of Total Housing Expenditures	Renovations As % of Total (Repairs, Improvements and Conversions)	Alterations, Improvements and Conversions as % of Total Renovations
	(1)	(2)	(3)	(4)	(5)	(1)÷(5)=(6)	(4)÷(5)=(7)	(2)+(3)÷(4)=(8)
1977	2,059,918	1,720,442	16,299	3,796,659	13,125,598	15.7	28.9	13.2
1978	2,329,408	2,019,277	21,683	4,370,368	13,911,758	16.7	31.4	14.7
1979	2,649,237	2,249,932	28,986	4,928,155	14,324,803	18.5	34.4	16.0
1980	2,862,453	2,217,162	32,913	4,112,528	13,872,008	20.0	36.9	16.9
1981	3,220,357	2,455,175	50,325	5,725,857	16,359,859	19.7	35.0	15.3
1982	3,577,946	2,569,700	48,250	6,195,896	16,396,688	21.8	37.8	16.0

Source: Adapted from table received from Canada Mortgage and Housing Corporation.

POTENTIAL OF REHABILITATION MARKET

Perhaps the potential for rehabilitation is a better indicator of its importance. A 1978 study estimated that about 13% of Canada's 7.5 million units of housing stock were in need of rehabilitation (9). There exists no such estimate for the non-residential sector. However, a recent study contracted by the Division of Building Research, National Research Council of Canada, estimated that 15% of the industrial building stock, 10% of the institutional buildings, and 11% of the other non-residential building stock, had been built before 1947. In addition, 12% of marine construction, 7% of roads and bridges, 3% of water works and sewage plants, 41% of dams and originator projects, 2% of electric power plants, 10% of railroads, 0.62% of oil and gas plants, and 3% of "other" engineering construction, had also been built before 1947.

These statistics indicate vast potential for rehabilitation activity in Canada. However, it is yet to be seen how much of this potential will be translated into practice.

Lately, some doubts have been expressed about the potential market and effectiveness of rehabilitation activity. One source of doubt relates to the hidden costs of building rehabilitation (10). It is argued that if a decision to rehabilitate or rebuild is to be based on costs per year of useful life expectancy of completed projects, rebuilding is certainly more cost effective.

With this kind of reasoning, the choice is not between "rebuild" and "rehab", but rather when to rebuild. Rehabilitation according to this viewpoint is a temporary activity until rebuilding becomes either more viable or unavoidable. Furthermore, the argument goes on, the rehabilitation economies are false because the new materials are more energy efficient, of better quality and have higher strength-to-weight ratios than the old materials.

The foregoing argument, although convincing on the surface, ignores the fact that resources are limited and have alternative uses. The reuse or recycling of resources may save billions of dollars. Moreover, uncertainties and risks in estimating rehabilitation costs should not undermine the importance of rehabilitation. Analytical techniques to estimate rehabilitation costs should be developed. Recently, the National Bureau of Standards in Washington has made such an effort (11).

REHAB OR REBUILD?

The decision to invest in rehabilitation or rebuilding is a complicated one. Besides economic factors such as interest rates, initial costs, maintenance and operating costs, it depends on social and technical factors. In this paper, only economic factors are considered.

Most of the economic literature on the subject deals basically with a single equation model based on present value, i.e., comparing the present value of capital, maintenance and running costs of a rehabilitated building over its lifetime plus that of the to-be-built new building after the life of the rehabilitated building, with the present value of the proposed new building. The most popular equation used in the literature is that given by Needleman (12,13) and others (14,15). According to this equation, rehabilitation is a preferred choice if

$$C_r > C_m + C_r(1+i)^{-\lambda} + (D_a+D_h)\,\frac{[1-(1+i)^{-\lambda}]}{i} \qquad (1)$$

where:

C_r = cost of demolition and rebuilding

C_m = cost of rehabilitation or modernization

D_a = difference in annual running costs between the rehabilitated and rebuilt buildings

D_h = difference in rent for rehabilitated and rebuilt buildings

i = rate of interest or discount rate

One of the major drawbacks of this equation is that it does not take into account the behaviour of the investor. What does he try to maximize or minimize, or what is his objective when he is faced with various alternatives? Furthermore, the equation shows that an investor is faced with only two choices:

rehab or rebuild. It may very well be that the investor does not want to do either; he may wish to get out of the business either by selling or abandoning his property.

Sigsworth and Wilkinson (14) pointed out that this simple model gives undue support to rehabilitation because it does not take into account the capital value of the existing building in the right hand side of the equation. They also pointed out that ignoring the escalation of rebuilding costs after, say, λ years, would underestimate the profitability of rebuilding. Needleman accepted this criticism and in his 1968 article he suggested the substitution of $C_r\left(\frac{1+e}{1+i}\right)^{\lambda}$ for $C_r(1+i)^{\lambda}$ (16) where e is the rate of escalation of replacement costs. (For more on this and other points, see Bröchner (17).)

Finally, the single-equation framework cannot determine the time at which rehabilitation or rebuilding activities have to be undertaken. In this framework, the time has to be pre-specified.

The foregoing review indicates the need for an economic framework that is behavioural and that can determine the timing for rehabilitation and the economic life of buildings considered. A framework that can determine the optimum investment in rehabilitation is also required. One model that contains some of the elements of the behavioural framework is provided by Bröchner (17).

Behavioural Model

This model is behavioural in that it is based on the behaviour of the decision-maker, the owner of the building.

Assumptions. The model assumes that the owner of the building (owner-occupier or landlord) knows the choices facing him. Choices can be rehabilitation, rebuilding, or the status quo. His aim is to maximize the present value of net income (profits in the case of landlords, or opportunity profits in the case of the building owner, i.e., profits he could make if he were to rent his building to someone else). This framework also assumes that there prevails: 1) perfect competition in the market for new buildings — an owner can demolish his home and build it anew at a price his neighbour has to pay for the same kind of housing services, or he can rehabilitate his home at a price his neighbour has to pay for achieving the same kind of services for the same type of home; and 2) perfect competition in the credit market — all lending and borrowing rates are equal and an individual can borrow or lend as much or as little as he desires, constrained only by his ability to repay.

The model. This model seeks to maximize the present value of net income of the landlord over a given period of time. The net income in this case is derived by subtracting the cost of rehabilitation of the building at one time over its lifetime from the rental income plus the increase in site value of the building.

This objective function can be specified by the following equation:*

$$\mathrm{Max}_{\theta,T}^{L} = \int_0^\theta R_1 e^{-(i+\delta)t}\,dt + \int_\theta^T R_2 e^{-(i+\delta)t}\,dt - C(0)^{-(i+\mu)\theta}$$

$$+ S(0)^{(\gamma-i)T} \tag{2}$$

where:

R_1 = rental revenue less operating costs before rehabilitation

R_2 = rental revenue less operating costs after rehabilitation

$C(0)$ = rehabilitation cost in the initial period

$S(0)$ = salvage value or resale price valued at the initial period

θ = year in which rehabilitation to be carried out

i = a constant discount rate

δ = constant rate of physical depreciation (depreciation resulting from obsolescence is not considered.)

μ = rate of cost decrease of rehabilitation over a period of time. This assumes a gradual increase in government subsidies

T = terminal year in life of building

γ = rate of increase in site value of building.

All these values are expressed in constant dollars.

From equation 2, we can obtain the optimum value for θ by differentiating it partially with respect to Q and putting the outcome of the differentiation equal to zero.

$$\frac{\partial L}{\partial \theta} = (R_1-R_2)e^{-(i+\delta)\theta} + C(0)(\mu+i)e^{-(\mu+i)\theta} = 0$$

Solving it, we get $$\theta = \frac{1}{(\mu-\delta)} \log \left[\frac{C(0)(\mu+i)}{R_2-R_1}\right] \tag{3}$$

Equation 3 indicates that θ, the date of rehabilitation, will be postponed if rehabilitation costs and discount rates are high, but it will be advanced if there are large differences in the rental income levels after and before rehabilitation, provided the depreciation rate is lower than the rate of decrease in rehabilitation costs. A point worth noting is that the rehabilitation date does not depend on the life of the building. However, the life of the building is extended by rehabilitation. The extension in life can also be determined by subtracting economic life before rehabilitation from that after rehabilitation. Optimizing equation 2 with respect to T will give us optimum economic life of the building after rehabilitation

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*Adapted from Jan Bröchner (17).

$$T_a = \frac{1}{\delta+\gamma} \log \left[\frac{R_2}{S(0)(i-\gamma)}\right] \tag{4}$$

Similarly, by taking out the second item (i.e., rental income after rehabilitation) from equation 3 and differentiating the remaining component with respect to T will give us optimum economic life of the building without rehabilitation

$$T_b = \frac{1}{\delta+\gamma} \log\left[\frac{R_1}{S(0)(i-\gamma)}\right] \tag{5}$$

Subtracting 5 from 4, we get $T_a - T_b = \Delta T = \frac{1}{\delta+\gamma} \log\left[\frac{R_2}{R_1}\right]$ (6)

Equation 6 reflects two important points. First, the extension in economic life of the rehabilitated building does not depend on discount rate, nor on the cost of rehabilitation nor on initial site value. Rather, it depends on the ratio between rental revenue after and before rehabilitation, rate of increase in the site value, and the rate of depreciation. Second, expectations of high rental revenue after rehabilitation will prolong the economic life greatly. However, depreciation and increase in site value rates will shorten the extension of economic life of buildings.

HOW TO REHABILITATE AND HOW MUCH TO INVEST

Economic analysis can also be used to choose the most economical way of rehabilitating. There are several techniques that can be used to evaluate the various options. The most notable are life-cycle costing (LCC), benefit-to-cost-ratio (BCR) or savings-to-investment ratio (SIR), internal rate of return (IRR), and discounted payback period (DPB). (For a concise discussion of the meaning and application of these techniques, see (18).) The application of these techniques to rehabilitation varies from one situation to another. For example, if a homeowner wants to retrofit his home by raising the insulation level in the attic from the present R-12, he is interested in finding the optimum R level. The application of the LCC technique will provide that optimum R level at which total life cycle costs are minimum (or his net savings are maximum), other things being equal, or, in terms of incremental analysis, an optimum R level will be a point where no more net savings can be obtained by spending an additional dollar on insulation. (For more on the application of incremental or "marginal" analysis to retrofitting, see (19).) Similarly, if the homeowner has not decided how to rehabilitate his home for energy conservation, he may be facing the following options:

(a) replacement of existing oil-fired furnace with high efficiency natural gas furnace;

(b) addition of attic insulation to raise the current resistance level from R-12 to R-36;

(c) replacement of north-facing single-glazed windows with double-glazed ones.

In this situation, the application of the IRR technique would be appropriate. The competing options are not mutually exclusive and the budgetary constraints may or may not allow him to choose all these options. Hence, he has to rank the choices on the basis of rate of return. Using these rankings, he may combine the choices in such a way so as to exhaust the budget he has set aside for rehabilitation.

WHERE SHOULD WE GO FROM HERE?

The choice between rehabilitation and rebuilding is a complex issue that is difficult to resolve solely on the basis of mechanical formulations. Apart from economic aspects, the choice involves several social and human aspects, which have not been discussed in this paper. Undoubtedly, economic tools are useful in reaching "rehab"- or "rebuild"-related decisions, but in some situations their applications may not be conclusive. Where one side of the equation (discussed earlier) is not significantly different from the other side, it is hard to decide purely on the basis of economic factors. Similar problems are posed by the application of the LCC and IRR techniques. For example, a study of the Windsor Station in Montreal found that the criterion of internal rate of return on various roof rehabilitation alternatives did not provide a conclusive result. Among the six alternatives, two (asphalt shingles and slate) provided equivalent internal rates of return. The consulting firm consequently advised the client to base his choice on some other criterion along with the economic criterion.

More case studies should be undertaken to determine the effectiveness of economic factors in influencing the rehab versus rebuild decision.

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