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Ram Karan Sharma

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BENEFIT-COST ANALYSIS AND PUBLIC HEALTH: A CASE

STUDY OF THE TUBERCULOSIS CONTROL PROGRAM

IN ONTARIO, 1948 - 1966

by

Ram Karan Sharma

Department of Economics

Submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Graduate Studies
The University of Western Ontario
London, Canada

February 1973

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ABSTRACT

The main purpose of this dissertation is to develop and explain the methodology of applying benefit-cost analysis to public health projects and then to apply it to a specific case: the tuberculosis control program (TCP) in Ontario from 1948 to 1966.

The benefits and costs of the program as estimated in this study are the marginal benefits and marginal costs. To compute these marginal benefits and costs, 1948 is taken as the base line year from which the changes in benefits and costs are measured. It was in this year that (1) "wonder drugs" which revolutionised the treatment of tuberculosis were becoming generally available and (2) the federal government started giving grants to provinces to fight tuberculosis. Consequently, the "Extended Tuberculosis Control Program" was launched in Ontario. Ours is a study of the economics of this program.

The benefits of the project (B) are defined as all advantageous effects (in constant 1949 dollar terms) to society. They are given by the discounted value of the yearly marginal benefits flowing from: (1) Reduced Deaths (B_1); (2) Reduced Disability (B_2); and (3) Reduced Debility (B_3) due to control of tuberculosis in Ontario.

Disability is defined as sickness sufficient to cause absence from work. Debility does not cause absenteeism but reduces workers productivity on the job. It has not

been possible to estimate the social benefits of reduced debility. Therefore, the benefits as measured numerically are simply $B = B_1 + B_2$.

The costs of the project are total inputs of goods and services (in constant 1949 dollar terms) which had to be expended on the TCP in Ontario from 1948 to 1966. These costs include the costs of case finding, isolation and treatment. They are calculated by summing the costs incurred by various sources and agencies which spend on the TCP in Ontario.

Two sets of marginal costs are produced. One is computed by assuming that in the absence of the TCP total expenditure on tuberculosis in Ontario would have remained constant at the average level obtained in the last 3 years before the "Extended Program" was launched in 1948. The other is estimated on the assumption that not the total expenditure but the average per capita expenditure would have remained constant at the average level reached in those three years.

The results of our research are presented for the three main criteria of project selection: (1) Net Present Value; (2) Benefit-Cost Ratio; and (3) the Internal Rate of Return. Three different rates of interest -- 4, 8 and 15% -- are used for purposes of discounting in the case of net present value and benefit-cost ratio.

In each case we find that the investment of extra resources in the "Extended Tuberculosis Control Program"

in Ontario from 1948 to 1966 has been quite beneficial to society. Even when we do not count the incalculable gains made in human happiness and welfare and consider only the economic benefits achieved, the program turns out to be a profitable use of resources.

Moreover, our conclusion remains true even when the benefits of the program are adjusted downwards to take account of the improved medical technology resulting from the discovery of "wonder drugs".

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CHAPTER I

INTRODUCTION

Economists are becoming increasingly interested in doing research in problems pertaining to health and medical care. It has been recognized that health expenditures are not just welfare expenditures or transfer payments but represent an investment in human capital which can bring high returns to society. Health programs have contributed to economic growth in developed countries by not only increasing the numbers in the labour force and reducing the time lost due to sickness but also by improving the quality of labour. It has been shown that continuing improvement in the health of the people will remain an important factor in the future growth of economies like that of Canada and the U.S.A. For example, for the U.S.A., Denison estimates that if the death rate of the population under 65 is cut overnight by one-tenth, it will add 0.02 percentage points to the expected 1960-80 growth rate. He also measures the contribution that any change which cuts time lost from work because of sickness and accidents can make to economic growth of the U.S.A. He sums up his findings in the U.S.A. He sums up his findings in the following words:

Suppose lost time could somehow be cut one-fourth by 1980. This would raise labour input by 1.1 per cent, national product by 0.9 per cent, and the 1960-80 growth rate by .05 percentage points.¹

He gives estimates for the contribution made by education also.

This recognition of the part played by human capital in economic growth has helped economists solve the puzzle of observed divergence between increase in factor inputs -- labour time, natural resources and capital -- and the consequent increase in national income.² On the practical side, the effect of these findings has been the increase in expenditures incurred by governments in providing services like health and education.

Traditionally, health care in our society has been primarily an individual's responsibility. But over the years governments in almost all countries have started to take more and more interest in the general health of society. Many types of schemes for subsidizing private expenditure on health care have come in vogue in different countries. Consequently, there has been more and more public expenditure on health care. In Canada, for example, health expenditures by all levels of government (federal, provincial and municipal) have been going up in recent years: as a percentage of both the total government expenditure and the total health expenditure in the country. This is very clearly brought out by the data given in Table 1.1. In fact there are areas of health care where the provision of services must be undertaken by the government if they are to be provided at all. These areas collectively comprise what we call public health. Why the provision of public health services is necessarily to be left to government will be discussed in the next chapter. Suffice it to say

TABLE 1.1

TOTAL HEALTH EXPENDITURES BY ALL GOVERNMENTS
AND ALSO THESE EXPENDITURES AS PERCENTAGE OF TOTAL
GOVERNMENT EXPENDITURES AND TOTAL HEALTH EXPENDITURES

Year (1)	Expenditures on Health by the Different Levels of Government			Total (5)	Total Government Expendi- tures on Health (5) as Per- centage of Total Government Expenditure in the Country (6)	Total Government Expendi- tures on Health (5) as Per- centage of Total Public and Private Expenditure on Health (7)
	Federal (2)	Provincial (3)	Municipal (4)			
	(In Millions of Dollars)					
1947	57	87	27	171	5.5	38.1
1948	60	114	31	205	6.2	32.4
1949	69	156	38	263	7.1	43.3
1950	72	172	43	287	7.2	42.4
1951	82	190	51	323	6.5	42.2
1952	88	210	53	351	5.5	41.5
1953	94	229	54	377	5.7	40.0
1954	100	257	67	424	6.2	41.5
1955	103	271	69	443	6.1	39.4
1956	112	288	74	474	5.9	38.7
1957	118	332	85	535	6.2	39.8
1958	186	363	80	629	6.5	41.1
1959	280	470	72	822	7.9	49.6
1960	330	554	69	953	8.5	52.1
1961	429	621	72	1,122	9.3	55.9
1962	470	719	77	1,266	9.8	58.2
1963	-	-	-	1,334	9.8	54.6
1964	-	-	-	1,552	10.6	-
1965	-	-	-	1,674	10.4	-

Sources: (1) 1947-62, Eric J. Hansen, The Public Finance Aspects of Health Services in Canada, a study prepared for the Royal Commission on Health Services (Ottawa: Queen's Printer, 1963).

(2) 1963-65, Department of National Health and Welfare, The Economics and Costs of Health Care, Research and Statistics Memo (Ottawa: Department of National Health and Welfare, 1967).

Both these sources are quoted in T.J. Bourdeau, "Health Insurance and Choice Criteria: The Provincial Aspects", mimeographed.

here that the supply of public health services generates externalities on a large scale (cf., Ch. II); hence it is highly unlikely that the free market would allocate resources in this area in a socially efficient or optimal way.

Public health expenditure in Canada is generally between 10 to 15 per cent of the total government expenditure (excluding that on sanitation) on health. If we add to it the expenditure on sanitation -- sanitation and waste removal, after all, are an important part of public health services -- then the total public health expenditure forms about 20 to 30 per cent (though in some years it has been even more than 30 per cent) of the total government expenditure on health. The relevant statistics are presented in Table 1.2. Because this expenditure is undertaken by government on behalf of the public, as distinct from the expenditure incurred directly by the public in the market-place, there is no check, like profitability in the private sector, that resources are not being misallocated and wasted. In other words, in such cases we cannot use market-mechanism methods to find out whether the resources are being optimally used or not. Hence some other test of efficiency must be found. One of the methods employed to study efficiency in the use of government resources is benefit-cost analysis.

1. Previous Research and the Contribution of this Study

The main purpose of this dissertation is to develop and explain the methodology of applying benefit-cost analysis

TABLE 1.2

TOTAL GENERAL EXPENDITURE ON HEALTH
BY ALL GOVERNMENTS IN CANADA
BY FUNCTION, 1947-1962

Year (1)	Hospital Care (2)	Medical, Dental and Allied Services (3)	General and Public Health (4)	Total Excluding Sanitation (5)	Municipal Sanitation and Waste Removal (6)	Total Including Sanitation (7)	Expenditure on General and Public Health (4) as Percent- age of (5) (8)	Expenditure on General and Public Health and on Municipal Sanitation and Waste Removal (4)+(6) as Percentage of (7) (9)
	(In Millions of Dollars)							
1947	122	28	21	171	29	200	12.28	25.00
1948	145	30	30	205	35	240	14.63	27.08
1949	197	32	34	263	37	300	12.92	23.66
1950	215	34	38	287	41	328	13.24	24.08
1951	240	37	46	323	50	373	14.24	25.73
1952	259	41	51	351	53	404	14.53	26.23
1953	277	42	58	377	71	448	15.38	28.79
1954	315	47	62	424	140	564	14.62	35.81
1955	326	48	69	443	107	550	15.58	32.00
1956	348	53	73	474	130	604	15.40	33.60
1957	397	59	79	535	130	665	14.77	31.42
1958	481	61	87	629	130	759	13.83	28.59
1959	670	59	93	822	147	969	11.31	24.76
1960	786	66	101	953	153	1,106	10.60	22.96
1961	945	72	105	1,122	166	1,288	9.36	21.04
1962	1,071	90	119	1,280	177	1,457	9.30	20.31

Source: Columns (1) to (7), Eric J. Hansen, *The Public Finance Aspects of Health Services in Canada*, a study prepared for the Royal Commission on Health Services (Ottawa: Queen's Printer, 1963), Table 12, page 28.

Columns (8) and (9) have been calculated.

to public health projects and then to apply it to a specific case -- the Tuberculosis Control Program (TCP) in Ontario from 1948-1966.

There have been some economic studies of disease control programs in the past. In the U.S.A., Weisbrod tried to evaluate "quantitatively certain of the benefits to society of successful attempts to eliminate three specific diseases -- cancer, tuberculosis and poliomyelitis."³ Klarman has given estimates of potential benefits from eradication of syphilis.⁴ For Canada some estimates of the value of lost productivity from selected diseases for 1960-61 appear in the report of the Royal Commission on Health Services (Vol. 1).⁵ These selected diseases are mental illness, diseases of the circulatory system and cancer.

All these studies have been confined to evaluating the potential benefits from eradicating a specific disease in a certain year. As explained below this is not benefit-cost analysis in the real sense. No disease has ever been eradicated in one year and few have been eradicated at all. The level of control (eradication) chosen by Weisbrod, Klarman and the researchers for the Royal Commission is arbitrary in the sense that the optimum of resource input in a program may lie well short of the eradication. The Royal Commission's study on disease control programs suffers from another defect. In calculating the benefits from reduced mortality from those diseases, the U.S. data for the net present value of a human life -- developed by Weisbrod -- have been used. This procedure suffers from two main defects: (1) Weisbrod has used

1949 earning figures to make his calculations of the net present value of life-time earnings of males and females in the U.S.A. To use these obsolete data for measuring benefits of eradicating certain diseases in Canada does not seem justifiable; (2) use of the U.S. data would create a substantial upward bias in calculations of benefits from eradication of those diseases because earnings in the U.S.A. are (and have been) higher than in Canada. It may be argued that this upward bias in earning figures will be partially offset by the downward bias imparted to the life-time earnings data as the latter use 1949 earning statistics. It is true but the Commission fails to ascertain to what extent these biases offset each other. Thus, there is a need for such further studies of disease control programs, in Canada, as use up-to-date Canadian data.

For benefit-cost analysis in the field of disease control we have to estimate the time and resource inputs required to achieve a given level of control; and then to calculate the net present value of the streams of social benefits minus costs, $NPV(B-C)$, associated with the project over that period. As is indicated later in Chapter III, a project is worth undertaking only if $NPV(B-C) > 0$. Alternatively, we can calculate the benefit-cost ratio (B/C) ; i.e., the present value of the benefits divided by the present value of the costs of the program or we can calculate the rate of return on investment in the project. In the case of B/C , a project should be undertaken if $B/C > 1$. A project,

in the case of rate of return criterion, is selected if its rate of return is greater than a certain chosen rate.*

As far as we are aware, no studies have been done which investigate whether any of the above criteria have been met for the allocation of funds to disease control projects in Ontario or in any other province of the country. In the U.S.A., recently some cost-benefit studies of selected disease control programs have been done in the Department of Health, Education and Welfare (HEW). For example, benefit-cost ratios (B/C), i.e., the present value of the total benefits divided by the present value of the total costs of the program, have been calculated, on identical life-time earnings and identical discount rates, for programs aimed at controlling arthritis and cancer of specific sites. Such ratios were developed in other studies too including the studies on motor vehicle injuries and vocational rehabilitation services.⁶ It may, however, be added that it will be better if we calculate NPV(B-C) of a disease control program rather than its B/C. Relative merits of NPV(B-C) and B/C as a criterion of measuring investment worth of a project have been discussed extensively in the literature and are referred to in Chapter III.⁷ In some other HEW studies costs were measured in dollars but benefits were expressed in terms of reduced mortality and morbidity. Examples of such studies are maternal and child health care

*These three criteria of project selection have been discussed in detail in Chapter III.

programs and delivery of health services for the poor.⁸ Klarman et al. also follow such a procedure in their study on the treatment of chronic renal disease. They have expressed benefits in terms of life years gained.⁹ In these studies, the researchers have used Cost-Effectiveness Technique rather than Benefit-Cost Analysis. The former is different from the latter: in its use the inputs are measured in dollar terms but the outputs are expressed in kind (deaths prevented, years added to life, children educated and the like).¹⁰

In our study it is the benefit-cost analysis which has been used. The results of our research are reported for all the three criteria of project selection referred to above. All costs and benefits are measured in constant (1949) dollars. In doing so we have attempted to bring to bear on the analysis all of the main economic factors involved in this program. The aim is to discover on economic grounds alone the extent to which this program is a good investment.*

Moreover in programs like the Tuberculosis Control Program (TPC) in Ontario, which have been in existence for a long time, what is important is the comparison of marginal** (incremental) benefits accruing from marginal** (incremental)

*The main objective of such programs is to make gains in human happiness and welfare. These values, however, are incalculable. When it turns out that these values are accompanied by positive economic gains, society can pursue them with increased vigour, knowing that it is thereby opening the doors to further welfare possibilities.

**By marginal we mean any finite incremental or decremental change. We have used this term in a slightly different than the conventional sense. In the latter it indicates a very small change.

costs rather than the comparison of total benefits and total costs. The latter may give us misleading results. From the policy point of view, the more relevant question in case of such projects is not whether we should start them or not but whether we should spend more or less on such projects. This fact has been recognized in the literature. For example, Warren F. Smith observes:

Comparing total rather than only marginal costs is an error that is difficult to avoid. What should be analysed is the effect of change from the present situation, both in new benefits and new costs.¹¹

Therefore, the benefits and costs of the project as measured in our study are the marginal benefits and marginal costs. As will be explained later, in our research 1948 is treated as the base line year from which the changes in benefits and costs are measured.

As far as we are aware this is the first time that benefit-cost analysis of a disease control program is being done in terms of the marginal benefits and marginal costs.

2. A Few Points of Measurement and Terminology

A distinction has been made between eradication of tuberculosis and its control. Theoretically, eradication cannot be achieved in a given area as long as the tubercle bacillus* has not been completely eradicated from that area and also from the adjacent areas. This is because infection may come easily from adjoining areas especially in these days

*It is a bacterium that causes tuberculosis.

of rapid transportation and hence of great mobility of population from one area to another. To achieve eradication in this sense seems to be impossible. Dr. Johannes Holms, one-time chief medical officer of the tuberculosis unit of the World Health Organization (WHO), and in 1961 the chief executive director of the International Union Against Tuberculosis, suggested the following alternative definition of eradication:

I propose that tuberculosis eradication be considered attained when, in a total population within a large geographically defined area, a case of tuberculosis disease has become a medical curiosity.¹²

Even on the basis of this definition, Ontario, and for that matter the rest of Canada, is far from the stage where tuberculosis has been eradicated. And given the trends of morbidity* (prevalence of disease), it is not likely to be achieved for quite some time to come. It has been noted that the rate of decline in tuberculosis in Ontario has slowed down. For example, Dr. Rorabeck, the chief of the Tuberculosis Prevention Division, Ontario Department of Health, observes that at present we "find ourselves in orbit circling the problem but achieving little apparent headway towards the ultimate goal of control and eradication. The number of cases of active tuberculosis reported each year in Ontario has shown no appreciable change during the past five years."¹³

*The dictionary defines morbidity as prevalence of disease. But medical experts sometimes use the term to signify incidence of a disease. The difference between prevalence of a disease and its incidence is explained on next page.

It is because of these considerations that we have decided to undertake a study of the economics of the TCP as it has existed in Ontario, as distinct from the economic analysis of a theoretical program which might aim at achieving the still unrealistic goal of tuberculosis eradication.

A tuberculosis control program can be defined as "the sum of organized effort aimed at diminishing, within a given community, tuberculosis mortality, incidence and prevalence* and thereby the risk of infection."¹⁴ The term "control" in this sense can be treated as one definable in terms of varying degrees of control and this is how we have used it in this study. This usage of the term "control" must be distinguished from its use by certain authorities who define it in an all-or-nothing sense. For example, to decide whether tuberculosis has been controlled or not, WHO has stipulated a criterion which states that "a country (or province) has control of tuberculosis when not more than one percent of children of school leaving age are positive to the tuberculin tests."¹⁵

There seems to be some difference of opinion among the experts with respect to the exact meaning of "school leaving age". Dr. Rorabeck takes it as 13 years of age;

*The term mortality means the number of deaths, in a given area, in a year; incidence indicates the number of new cases developing in a year whereas the prevalence signifies the total number of all living cases (of tuberculosis in our case) in that year. See also Chapter IV, pp. 97-98.

Dr. C.A. Wicks defines it as 16 years and Dr. Holm, who first proposed the WHO measure of tuberculosis control interprets it as 14 years of age.¹⁶ This WHO criterion of the success of a tuberculosis control program in an area in any case would have to be accepted with some degree of caution. As Dr. Rorabeck points out, it is valid only when tuberculosis is well under control in adults and younger children. He gives the example of an area in which the tuberculin positive rate of school leavers had fallen to 0.5 per cent but the incidence of active tuberculosis increased from 10.0 per 100,000 in 1964 to 40.0 in 1965, largely because of new active cases* in children below 13 years of age.¹⁷

On the basis of the above WHO - criterion of T.B. being under control, Ontario can be said to be near to achieving control of tuberculosis in the province. In 1958-59 the rate of tuberculin-positive children in the age group of 10 to 14 years was 2.6 per cent.¹⁸

3. Tuberculosis Control Program in Ontario

The success of a tuberculosis control program in any area depends on effective case finding and adequate facilities for treatment. The basic philosophy of tuberculosis control, to quote Dr. Rorabeck, "is case finding, isolation where required, treatment and examination of contacts,..."¹⁹

*A new active case of tuberculosis is usually defined as a case which was never before reported as active, even though it may have been active at some earlier time. See Tuberculosis Statistics, 1968 (2 vols.; Ottawa: Dominion Bureau of Statistics), I, 10.

Ontario has an impressive record in its tuberculosis control.²⁰ The degree of control has improved substantially even if "control" in the WHO sense has not been attained. The first known collective effort for this purpose was made in 1897 when a voluntary organization -- The National Sanitarium Organization -- established the Muskoka Cottage Sanitarium. In 1912 the reporting of tuberculosis was made compulsory. In 1935 the Tuberculosis prevention Division of the Ontario Department of Health was established under the directorship of Dr. G.C. Brink.

This Division heads the province's antituberculosis program and is responsible generally for all measures relating to the prevention and treatment of the disease and the rehabilitation of the patient.* For this purpose it undertakes a number of activities.²¹

Another milestone in Ontario's organized efforts against tuberculosis took place in 1938. Before that the provincial government used to pay \$5.25 per week per patient for the maintenance of patients in sanatoria. Another \$10.50 per week per patient was supposed to be paid by the counties and local municipalities. But the latter were hard pressed

*Since April 1950, vocational rehabilitation of tuberculosis had been assisted and supervised by a rehabilitation section in the T.B. Prevention Branch; but since September 1960 this program has been transferred to the newly created Rehabilitation Branch. This Branch provides assistance to the tuberculous and mentally ill. See W.G. Brown, "The Ontario Department of Health", in The Federal and Provincial Health Services in Canada (2nd ed.; Toronto: Canadian Public Health Association, 1962), p. 82.

for money and in many cases municipalities imposed harsh conditions of dire poverty to be satisfied by a patient before he could qualify for financial support. Consequently, most of the patients in the province did not get proper treatment.²² In 1938 the provincial government assumed the financial responsibility of maintaining non-paying patients in sanatoria. It previously had been borne by the counties and municipalities. At the same time arrangements were made for post-sanatorium care which was defined as the provision of:

1. Transportation from the sanatorium to the place of residence;
2. Proper living accommodation, food, clothing and any other necessities of life;and
3. Special treatment for tuberculosis and transportation to and from any place at which such special treatment is available.²³

Special treatment in this context meant giving pneumothorax refills from time to time to some patients who required them after being discharged from sanatorium. The government established pneumothorax refill centres (78 in number) under the supervision of local physicians specially trained for this purpose. It loaned pneumothorax machines to these physicians and paid for their services.* Since 1938 tuberculosis treatment in Ontario is "virtually free**".

*After the discovery of "wonder drugs", pneumothorax treatment generally is not required.

**The Ontario government pays for most of the sanatorium expenses. There is no means test. In 1953, the fees from paying patients met only about 5% of the total sanatorium expenditures in Ontario.

although if a patient can contribute towards the cost of his treatment he may be asked to do so.²⁴

On the case finding front also, the province has put in commendable efforts. Mass X-ray surveys were first introduced in Ontario in 1941. They were greatly facilitated by the introduction of special miniature film X-ray equipment. In the beginning they were confined to adult occupational groups like teachers but later on with the help of voluntary associations they were extended to the general public. They are mostly free of any charge to the public. If any abnormality is found, the patient is called for another chest X-ray and more detailed study of this case is made.

In 1948, a program to give all patients entering general hospitals chest X-rays was introduced. Funds from federal grants for antituberculosis programs were used for this purpose. After 1948, the year the federal government started giving grants to provinces for antituberculosis programs, several other steps were taken by the province to advance its antituberculosis program. For example, in 1949 in the Tuberculosis Prevention Division, a branch for rehabilitation of ex-patients was established. As stated earlier, since September 1960, this aspect of the anti-tuberculosis program is being looked after by the newly established Rehabilitation Branch. Since 1950, tuberculosis has become a compensable disease for all employees of hospitals and sanatoria. Compensation is paid through the Workman's Compensation Board.

4. 1948: A Year of Breakthrough

In fact a real breakthrough in Ontario's tuberculosis control program occurred in 1948 when the province embarked upon what has come to be known variously as the "Extended Tuberculosis Control Program" or the "Accelerated Tuberculosis Control Program". As mentioned above, it was in 1948 that the federal government started giving annual grants-in-aid to provinces for TB control. These grants were provided under the federal government's National Health Grants Program. The purpose of Tuberculosis Control Grants was "to assist in an extended program for the prevention and treatment of tuberculosis; including rehabilitation and free treatment."²⁵ That the federal grant gave a real boost to the tuberculosis control program in Ontario becomes clear from the nature and importance of projects which were financed from it. Among the projects supported in Ontario by this grant were:

- "(a) Streptomycin and para-amino salicylic acid (PAS was made free to all sanatorium patients.
- (b) Purchase of X-ray equipment for use of clinics, hospitals, and the hospital admission X-ray programme.
- (c) Purchase of complete X-ray unit, bus and equipment to be added to the mobile fleet of buses of the Division of Tuberculosis Prevention.
- (d) Expenses of research programmes."²⁶

In addition to this, the federal government also helped antituberculosis control programs in the provinces by making funds available for extension and construction of sanatoria under its Hospital Construction Grants.

It was also in 1947-48 that the "wonder drugs" for curing tuberculosis were becoming generally available. There are now three principal drugs used in the cure of tuberculosis: (1) Streptomycin, (2) Para-Amino-Salicylic Acid (PAS), and (3) Isoniazid. Streptomycin and PAS were introduced in 1944 -- Streptomycin in the U.S.A. and PAS in Sweden.²⁷ But it was not before 1947-48 that there occurred a real breakthrough in the use of these drugs for curing T.B. For example, Hinshaw, one of the pioneers in chemotherapy of tuberculosis observes that, "during 1945 and 1946 supplies of streptomycin were extremely scarce and ... its use was limited to those cases which would enhance our knowledge of chemotherapy of tuberculosis."²⁸

Moreover it was about this period that it was found that the treatment of T.B. became much more effective when PAS and streptomycin were used in combination than when either of them was used alone. It was suspected in 1946 that combined treatment would give better results but this fact became firmly established in 1949 only.²⁹ Isoniazid, the third principal drug, first became commercially available in 1952.³⁰

Thus 1948 marks the beginning of an important era in the tuberculosis control program in Ontario and for that matter in the rest of Canada. Not only had the antibiotics, which revolutionized tuberculosis treatment, become accessible in that year but funds were also being made available to render those drugs more widely available to those who needed

them. Provision of finances to make use of these "wonder drugs" was very important because initially they were quite costly. Commenting upon the use of streptomycin in the early years of its availability, Dr. Forsberg (a staff member of the Tuberculosis Prevention Division in Ontario) made the following observation:

Streptomycin Calcium Complex was used sparingly in 1946 and 1947. The prohibitive cost still restricted its use until July, 1948 when the Ontario Department of Health agreed to supply free streptomycin by utilizing monies from the Federal Tuberculosis Grant. Its use trippled immediately and has remained at a high level ever since.³¹

Along with facilitating the tuberculosis treatment federal funds also helped provinces accelerate their case finding efforts.³² It is because of these factors that we decided to take 1948 as the starting year for our study. The marginal resource input that we examine in this study is the difference between the annual actual expenditures in the post-1948 years and the yearly expenses which would have been incurred had the expenditures been frozen at their 1948 level. The marginal benefits as measured in this study also have a similar definition.

1966 was chosen as the end-year of our study because by this time the treatment of tuberculosis had become so much revolutionized that institutional statistics (which are used in this research) by themselves did not give any longer an almost complete indication of the magnitude of the tuberculosis problem in the province and of the resources used to control it. Patients were being given drug therapy on an out-patient

basis. The role of sanatoria in the treatment of tuberculosis was on the decline. So much so that in 1967 the province of Ontario issued a directive to effect a cutback on sanatoria in the province.³³

5. Why Choose Tuberculosis?

The Tuberculosis Control Program in Ontario is selected for this study for a number of reasons:

1. The required data for the study are generally available.
2. Tuberculosis remains in Ontario and elsewhere a major health problem. Although the tuberculosis death rate in Ontario declined from 19.3 per 100,000 in 1948 to 2.6 in 1962 (corresponding figures for Canada were 38.1 and 4.2 respectively), yet with respect to morbidity tuberculosis is still a public health problem of considerable importance.³⁴ The number of new cases remains high and reactivations are substantial.
3. Government along with voluntary associations spends large amounts of money on tuberculosis prevention. The examination of a suspected patient and hospitalization of a patient with TB are compulsory in Ontario. Provisions for this purpose have been made in the Public Health Act and the Sanatoria for Consumptives Act.³⁵ As stated earlier, expenses for treatment are largely paid out of public funds.
4. There is some prima facie evidence of under-utilization of facilities for institutionalized treatment of TB in

Ontario* and in Canada as a whole because of the fall in the number of patients.

The under-utilization of present facilities, as far as tuberculosis treatment is concerned, indicates that the program has substantially achieved its goal. The interesting question now is to determine through benefit-cost analysis the extent to which the tuberculosis control program has been an economically efficient use of resources. As mentioned before, this is over and above the incalculable gains made in terms of human happiness.

*Suggestive evidence of this is provided by the number of empty beds in the sanatoria in the province and the actual closing of some sanatoria.

FOOTNOTES

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³Burton A. Weisbrod, Economics of Public Health (Philadelphia: University of Pennsylvania Press, 1961), p. ix.

⁴Herbert E. Klarman, "Syphilis Control Program", in Measuring Benefits of Government Investments, ed. by Robert E. Dorfman (Washington, D.C.: The Brookings Institution, 1965), pp. 367-410.

⁵Royal Commission on Health Services, Report of the Commission (2 Vols.; Ottawa: Queen's Printer, 1964), I. 517.

⁶U.S. Department of Health, Education and Welfare, Office of the Assistant Secretary for Program Co-ordination, Cancer, Program Analysis, Disease Control Programs, No. 1966-3; Arthritis, Program Analysis, Disease Control Program No. 1966-4; Motor Vehicle Injury Prevention Program, Program Analysis, Disease Control Programs No. 1966-1 (Washington, D.C.: Government Printing Office, 1966); U.S. Vocational Rehabilitation Administration, An Exploratory Cost-Benefit Analysis of Vocational Rehabilitation (Washington, D.C.: Government Printing Office, 1967).

⁷Rolland N. McKean, Efficiency in Government Through Systems Analysis (New York: John Wiley and Sons, Inc., 1958); Public Spending (New York: McGraw-Hill Book Co., 1968); Harold Bierman, Jr. and Seymour Smidt, The Capital Budgeting Decision (New York: The Macmillan Company, 1968).

⁸U.S. Department of Health, Education and Welfare, Office of the Assistant Secretary for Program Co-ordination, Maternal and Child Health Care Programs, Program Analysis, Disease Control Programs No. 1966-6 (Washington, D.C.: Government Printing Office, 1966); Delivery of Health Services for the Poor, Program Analysis, Human Investment Programs, No. 1967-12 (Washington, D.C.: Government Printing Office, 1967).

⁹Herbert E. Klarman, et al., "Cost-Effectiveness Analysis Applied to the Treatment of Chronic Renal Disease", Med. Care, 6 (January-February, 1968), 48-54.

¹⁰Harold A. Hovey, The Planning-Programming-Budgeting Approach to Government Decision-Making (New York: Frederick A. Praeger, 1968), pp. 45-46, and 55-56; William A. Niskanen, "Measures of Effectiveness" in Cost-Effectiveness Analysis, ed. by Thomas A. Goldman (New York: Frederick A. Praeger, 1967), p. 18.

¹¹Warren F. Smith, "Cost-Effectiveness and Cost-Benefit Analysis for Public Health Programs", Public Health Reports, 83 (November, 1968), 901.

¹²Johannes Holm, "The Eradication of Tuberculosis", in Tuberculosis: Prevention and Control (London: The Chest and Heart Association, 1962), pp. 10-14.

¹³C.H. Rorabeck, "Tuberculosis Control: Dream or Probability", CJPH, 60 (January, 1969), 43.

¹⁴Holm, "Eradication of Tuberculosis", p. 10.

¹⁵G.J. Wherrett, Tuberculosis in Canada, a study prepared for the Royal Commission on Health Services (Ottawa: Queen's Printer, 1964), p. 49.

¹⁶C.H. Rorabeck, "Tuberculosis Control: The Great Delusion", CJPH, 57 (September, 1966), 421; C.A. Wicks, "comments on Tuberculosis Control", CJPH, 54 (October, 1963), 447; Holm, "Eradication of Tuberculosis", p. 11.

¹⁷Rorabeck, "Great Delusion", 421.

¹⁸Wherrett, Tuberculosis in Canada, table 3, p. 5.

¹⁹Rorabeck, "Dream or Probability", 43.

²⁰Most of the facts on the T.B. Control in Ontario are based on: Ontario Department of Health, Division of Tuberculosis Prevention, Outline of Tuberculosis Programme in Ontario, (Toronto: Ontario Department of Health, 1950); G.C. Brink, Across the Years: Tuberculosis in Ontario (available from Toronto: Ontario Tuberculosis Association); Department of National Health and Welfare, Research and Statistics Division, The Administration of Public Health in Canada, Health-Care Series No. 3 (Ottawa, Department of National Health and Welfare, 1958).

²¹For the activities of this Division see Ontario Department of Health, Outline, 30-31; W.G. Brown, "The Ontario Department of Health", in The Federal and Provincial Health Services in Canada (2nd ed.; Toronto: Canadian Public Health Association, 1962), p. 83.

²²In 1937 it was found in a survey that "not more than 50% of residents of the province dying of tuberculosis had been treated in sanatoria," and that "fewer than 50% of the patients recommended for sanatorium care by the departmental clinics were admitted within one year." See Brink, Across the Years, p. 21.

²³Ontario Department of Health, Outline, p. 4.

²⁴Department of National Health and Welfare, Administration of Public Health (Ottawa: Department of National Health and Welfare), p. 40.

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²⁶Brink, Across the Years, p. 25.

²⁷Kjeld T. Orning, "The Twenty Fifth Anniversary of Para-Amino-Salicylic Acid and Streptomycin", Scandinavian Journal of Respiratory Diseases, 50, No. 3 (1969), 210-211.

²⁸H. Corwin Hinshaw, "Tuberculosis Chemotherapy: Reminiscence of Early Clinical Trails", Scandinavian Journal of Respiratory Diseases, 50, No. 3 (1969), 197-203.

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³³James Tost, "Last TB Patient Leaves Royal Ottawa", Ottawa Journal, May 30, 1970, p. 39.

³⁴Wherrett, Tuberculosis in Canada, table 4, p. 11.

³⁵Ontario Department of Health, Outline, pp. 24-25.

CHAPTER II

THE ROLE OF GOVERNMENT IN PUBLIC HEALTH

We have already shown (chapter I) that in Canada the government's role in providing health services is becoming more and more significant over time. Health services provided by the government can be broadly put into three main categories: (1) Public Health; (2) Medical Care; and (3) Hospital Care.¹ Our main concern here is with public health. We asserted earlier that the public health services were necessarily to be provided by the government (see supra, p. 2). In this chapter we explain the meaning and nature of what we have called public health and also provide a rationale for government's intervention in its provision.

1. Public Health

The definition and scope of public health have been undergoing a change. At different times several authorities gave different definitions of public health:

1. Public health is communicable disease control.
2. Public health is sanitation of the environment.
3. Public health is medical care of the medically indigent.²

But the scope of public health in modern times is much wider than that indicated by any one of the above definitions and thus none of them can be treated as proper and all-comprehensive. On the other hand a definition given by WHO is rather too broad. According to the WHO Expert Committee on Public Health Administration, it is "the science and art

of preventing disease, prolonging life, and promoting health and efficiency through organized community efforts for the sanitation of the environment, the control of communicable infections, the education of the individual in personal hygiene, the organization of medical and nursing services for the early diagnosis and preventive treatment of disease, and the development of social machinery to ensure for every individual a standard of living adequate for the maintenance of health, so organizing these benefits as to enable every citizen to realize his birth-right of health and longevity."³

This definition of public health, as Eric Hansen has rightly pointed out, includes implicitly all health and public welfare services.⁴ The latter may promote health but obviously cannot be treated as health services. A very precise and apt definition has been given by the Royal Commission on Health Services. According to it, public health comprises

...any health problem that involves a sufficient number of individuals to become a public problem, and for the adequate solution of which public action is necessary or desirable.⁵

In this category of health services we might include not only the public sanitation, communicable disease control etc. (the traditional functions of any public health department in any country) but also the provision of cancer research facilities, mental health clinics, and tuberculosis clinics, etc.

2. The Rationale for Government's Role in Public Health

The question is why should government get involved

in providing any health services? Government's intervention in the provision of any good or service can generally be supported on the basis of three main economic considerations taken either singly or collectively: (1) a good or service may exhibit "publicness"; (2) its production or consumption gives rise to externalities;* and (3) it can only be produced under increasing returns to scale.

We will now discuss how far any one of these problems or all of them are operative in the case of public health services and hence to what extent government must intervene in supplying them to society. It, however, should be clarified at the very outset that by government intervention we do not necessarily mean the production of a good in the public sector. Government might produce the commodity in question or it may simply try to bring its production in the private sector to the socially optimum level via a policy of taxes and subsidies. Whatever policy the government might adopt, it is obvious that use of public funds will be involved.

2.1 Public Health as a Public Good

Traditionally, government's intervention in the production of a commodity or service has been justified on the basis of externalities arising out of its production (or consumption) and/or the prevalence of decreasing cost conditions in its production.⁶ Later on Samuelson, inspired

*For a distinction between publicness and externalities see pp. 40-41.

by the researches of Musgrave and Bowen, developed a theory of public expenditure based on the concept of a "polar case" public good, defined as one for which each individual's consumption equals the total produced.⁷ His theory started a debate (about the nature and supply of public goods) which is still going on.

Samuelson showed that if we introduced a public good in our analysis the problem of attaining Pareto-Optimality becomes even more difficult than in the standard welfare theory.

Given an n individual and a two good world (with both goods strictly private) in a closed economy, perfect competition with no externalities or its administrative equivalent (e.g. a situation in which Lange-Lerner civil servants administer the system through shadow prices) can be counted upon to satisfy the relevant Pareto-Optimality condition if we have fixed factor supplies:

$$MRT_{xy} = MRS_{xy}^1 = MRS_{xy}^2 = \dots = MRS_{xy}^n \quad (2.1)$$

where

MRT_{xy} = Marginal rate of transformation between goods x and y

and

$MRS_{xy}^1, MRS_{xy}^2, \dots, MRS_{xy}^n$ etc. = Marginal rate of substitution between goods x and y for individual 1, 2, ..., and n respectively.

But if one of the goods is a public good, the Pareto condition becomes (Samuelson showed):

$$MRT_{xy} = \frac{n}{1} MRS_{xy} \quad (2.2)$$

and no analogue of perfect competition is practicable to enable an economy to arrive at states in which this condition is fulfilled. He points out, in particular, that the solution -- if optimal output is to be achieved -- in this case cannot lie in multiple pricing related to preference because in the case of a public good it is in the self interest of every individual not to reveal his true preference for that good. A major inference that we can draw from his analysis is that the function of providing Samuelson's public goods to the community has to be taken up by government. Left to the free working of the market process these goods will not be produced in the optimal quantity, if they are produced at all. It, therefore, follows that to the extent that public health is a public good or has the qualities of "publicness", government has necessarily to assume a role in its provision. So our aim now is to investigate whether or not public health has the characteristics of a public good.

Let us quote Samuelson's definition of public goods:

I explicitly assume two categories of goods: ordinary private consumption goods (X_1, \dots, X_n) which can be parcelled out among different individuals (1, 2, ..., i, ..., S) according to the relations $X_j = \sum_{i=1}^S x_j^i$ and collective consumption goods (X_{n+1}, \dots, X_{n+m}) which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtraction from any other individual's consumption of that good, so that $X_{n+j} = x_{n+j}^i$ simultaneously for each and every i th individual and each collective consumption good.⁸

It is clear from this definition that a public good once produced is available to all in equal quantities at the same time, i.e. more for me does not mean less for you. In other words one individual's consumption of a public good is related to the total production by a condition of equality and not (as in the case of a private good) by that of summation.⁹

Samuelson's definition implies -- it has been shown in the literature -- joint supply.¹⁰ Joint supply, however, in this context has to be carefully distinguished from normally discussed joint supply analysis as presented by Marshall in his Principles. Buchanan in his recent book makes this distinction very clear. He puts it as follows:

For the Marshallian theory the jointness of supply arises because of the technological conditions of producing, not because of the technological condition of consuming as in the public goods case ... [In the Marshallian Case] the joint-supply analysis is illustrated with reference to final product components that are subject to retrade or resale among potential purchasers ... [but] in the public-goods case, the jointness arises only because of the indivisibility or the non-exclusion in consumption.¹¹

And from this he concludes that "an element of determinacy is present in the Marshallian model which is lacking in the public goods model."¹² Jointness of supply in the public goods case implies its equal availability to all members of the (relevant) group or community, or in other words "a single unit of the good, as produced, provides a multiplicity of consumption units, all of which are somehow identical."¹³ In such a case once the good is produced it can be provided to another individual at zero marginal cost.

In order to avoid confusion we will use the term joint consumption instead of joint supply. Given this characteristic of joint consumption in a good it will not be produced in the optimal quantity by profit motivated private enterprise (if it is produced at all) because as explained earlier, an individual working in his self-interest may like to enjoy a "free ride".

When we consider public health in relation to this joint consumption aspect of public goods we find that this field of government services does not entirely correspond to the situation described. But the pertinent question is how many goods can be categorized as public goods on the basis of this very stringent and restrictive definition of a public good. Samuelson gives the examples of an "outdoor circus", "national defence", a "battleship" and a television programme".¹⁴ But further thought will show that even these examples do not satisfy to perfection the extremely demanding conditions set by the above definition of public goods. Samuelson's definition was criticized by many, including Stephen Enke, Julius Margolis and John G. Head, on this score.¹⁵ It was pointed out that "capacity limits" are reached much before the good satisfies the condition of equal availability to all and also that the quality of the good may vary even before the capacity limit is reached. Samuelson has agreed to this type of criticism and has called his definition an "extreme polar case" as against the other extreme case of a private good.¹⁶ But, according to

him, "in almost every one of the legitimate economic functions of government that critics put forward there is to be found a blending of the extreme antipodal models."¹⁷ Thus the quality of joint consumption remains an essential characteristic of a public good. But the meaning of joint consumption is modified as being more for you means no less for me to some extent, i.e. unless the "capacity limit" is reached.¹⁸ In fact in the literature on public goods two types of public goods are now distinguished from one another:

- (1) Pure Public Goods -- goods which satisfy Samuelson's condition of "equal availability to all" in toto. Very few goods satisfy this condition.
- (2) Impure Public Goods -- goods which exhibit the quality of publicness in an impure form. Impurity or imperfect publicness in this context is defined "as any departure from the availability of "equal quantities of homogeneous-quality consumption units" to all consumers."¹⁹

It is in this sense of impure publicness that some of the services in the public health field have the joint consumption characteristic of a public good. Consider, for example, the case of Tuberculosis Sanatoria. They are available to all patients; but beyond a certain point additional consumption by one person does entail a corresponding reduction in the consumption of others. Take another example from public health, a spraying campaign to kill flies and mosquitoes. Benefits of this campaign are equally available to all but the quality of the benefits goes on diminishing

as we go farther and farther away from the area where the chemicals have been sprayed.

Even if a good is an impure public good it pays an individual consumer to understate his preference for it because once it has been made available to one it will be available to him though not in the same quantity and quality. It will, therefore, never be produced in an optimal quantity if its production is left to private entrepreneurs in a free market economy. Government intervention in its production becomes essential and hence the government's intervention in the provision of public health services is necessary.

2.2 Externalities

We have stated earlier that traditionally the presence of externalities in the production or consumption of a commodity or service was given as one of the important reasons for government intervention in its provision. It is well known now in the literature on public goods that such goods not only generally satisfy the quality of joint consumption but usually give rise to externalities (consumption externalities) also.

Samuelson's definition of a public good (see supra, p. 30) does not mention externality as one of the characteristics of a public good but John Head, after a careful analysis of Samuelson's three articles on public expenditure theory and by referring to various observations made by Samuelson in those articles, has rightly concluded that his (Samuelson's) definition of a public good and others given

in the literature imply two distinct characteristics of a public good: (1) Joint Consumption (Head calls it Jointness of Supply); and (2) Externalities or to be precise Consumption Externalities (see infra, pp. 36-37).

The concept of external economies has long been used by economists, but there still remains a considerable degree of confusion regarding its exact meaning. Some writers define externalities in such a way that they encompass all factors that give rise to market failure (i.e., the failure of the market to reach Pareto Optimality). For example, Bator's use of this concept can be interpreted in this way. He would "let externality denote any situation where some Paretian costs and benefits remain external to decentralized cost-revenue calculations in terms of prices." But, according to him, a technology exhibiting indivisibility or giving rise to smooth increasing returns to scale in the relevant range of output also gives rise to "technical externality".²⁰ This type of definition is rather too broad. Increasing returns to scale and indivisibilities are normally treated as distinct from the phenomenon of externality. Again, some writers let externalities denote any interdependence among economic units whether it is felt through the market or outside the market.²¹ Marshall, who first introduced the concept of externalities, gives some examples of this type of externality.²² Take the case of an industry which uses a large part of total supply of, say, steel. The expansion of this industry will raise the price of steel for

other industries. This effect on other industries is at times referred to as an example of "external diseconomy".* But this kind of "external diseconomy" creates no problems for the so-called central theorem of modern welfare economics, i.e., equilibrium conditions under perfect competition lead to Pareto efficiency.²³

We will apply the term externalities to cover all those interdependencies among economic units which are external to the price system, i.e., these are benefits and/or costs which are not captured by the participants in a market transaction. In other words we can say that external economies represent such cases of ordinary economic behaviour "where the production or consumption of a good by one economic unit confers benefits on other economic units, such that it is impossible or inconvenient for these external recipients of the benefits to be charged."²⁴ (Italics mine.)

Externalities can further be divided into: (1) production externalities; and (2) consumption externalities. Under perfect competition maximum welfare is achieved when:

$$\text{Marginal Social Cost (MSC)} = \text{Marginal Social Benefit (MSB)} \quad (2.3)$$

In a perfectly competitive market Marginal Private Benefit (MPB) = Marginal Private Cost (MPC). If MPC = MSC and MPB = MSB, we can write the above maximum welfare condition (2.3) in the following form:

*Externalities passing through price mechanism now are called pecuniary externalities as distinct from technical externalities which do not work through the price mechanism.

$$MSC = MPC = MPB = MSB \quad (2.4)$$

Because in an equilibrium under perfect competition $MPC = \text{Price}$, we can change (2.4) to the following:

$$MSC = MPC = MPB = MSB = \text{Price} \quad (2.5)$$

Now production externalities can be said to exist, in general, when $MPC \neq MSC$ and consumption externalities exist when $MPB \neq MSB$.*

Pigou was the most prominent economist to make this distinction between private and social costs and benefits well known and to emphasize the problem of externalities vis-a-vis their affect on Pareto Optimality.²⁵ He pointed out that because of the existence of externalities some activities in the economy will be over-expanded and others will be over-contracted from what would be desirable from the point of view of socially optimal output in the economy.

If we are to achieve Pareto Optimality in the economy ("ideal output" in Pigou's words) government intervention in the economy becomes necessary. In the absence of government intervention an individual consumer or a firm will use a good up to a point where

*In the literature on externalities, we find that usually four types of externalities are described: (1) producers externalities on producers; (2) producers externalities on consumers; (3) consumers externalities on consumers and (4) consumers externalities on producers. Out of them (1) and (2) are covered by what we have called production externalities and (3) and (4) are covered by what we have described as consumption externalities. But the externalities of type (4) are not very significant so we will use the term consumption externalities to describe externalities of type (3), and it is with these consumption externalities that we will be concerned in this chapter.

$$\text{MPB} = \text{MPC} = \text{Price} \quad (2.6)$$

But as we have indicated earlier (2.3, p. 36), a socially optimal production in a free market economy is achieved when $\text{MSC} = \text{MSB}$. This condition will not be achieved in a purely private economy if there are externalities present in the economy.

Government can intervene in the economy in one or more of the several ways open to it. For example, the government may (1) subsidize the production and use of those goods and services which create external economies and conversely it may tax the production and use of those goods and services which generate external diseconomies; (2) it may buy those goods or services (i.e. pay their producers) the production or use of which gives rise to external economies and make them freely available to the people; (3) it may itself produce the goods and services in question and provide them to the community free of charge.²⁶

Pigou's classic recommendation was to use the first of the above methods. Whether Pigovian Solution will help attain Pareto Optimality or not has been a matter of continuing controversy. We do not want to enter that controversy. It is sufficient to say, for our purposes, that whenever there are externalities government's intervention in one form or the other in the provision of goods and/or services becomes necessary.²⁷

An important and relevant question which remains to be answered is what gives rise to externalities. The

answer is provided by our emphasis on the words impossible and inconvenient in our definition of external economies (see supra, p. 36). In other words externalities arise largely because of the fact that it is not possible or economical for a person to charge, through the price mechanism, those who get benefit from his consumption or production nor is it possible or economical for them to get any compensation if they are adversely affected by his actions. McKean has put this in very clear terms:

One reason external effects exist is that the costs of defining, exchanging, and policing rights to benefits, or rights not to be afflicted with damages, sometimes exceed the gains to private groups from 'internalising' these effects.²⁸

Externalities in this sense are clearly identical to what has been called the "impossibility of exclusion". Exclusion principle in this context means that a person is "excluded from the enjoyment of any particular commodity or service unless he is willing to pay the stipulated price to the owner."²⁹ Musgrave in his definition of a public good emphasizes, along with joint consumption, the fact that public goods usually cause consumption externalities. He does not use the term public goods but rather calls them goods that satisfy "social wants" and says:

Social wants are those wants satisfied by services that must be consumed in equal amounts by all. People who do not pay for the services cannot be excluded from the benefits that result.³⁰

That Musgrave considers consumption externalities as one of the important characteristics of a public good becomes very clear from his new book.³¹ While discussing

the distinction between private and social (public) goods he observes that benefits from public goods are "nonrival", i.e., the benefits from a public good to an individual A are not reduced by B's sharing therein.³² But he also emphasizes the externality aspect of public goods. Actually he emphasizes it so much that he considers externality (consumption externality) as the sole criterion of distinction between public and private goods. Consider for example, this observation made by him: "The distinction between private and social wants or goods depends on whether the resulting benefit is internal or external."³³

He echoes the same sole emphasis on the externality aspect of the characteristics of public goods when he concludes his section (in his book) on "social versus private wants" by saying that the difference between social and private wants "lies in the externality characteristics of the goods needed to satisfy the two types of wants. It is not a matter of ideology but an objective or "technological distinction".³⁴

We believe that Musgrave in his recent book has rather over-emphasized the externality characteristic of a public good. Even pure private goods can create externalities. A handsome private house or a beautiful lawn can give pleasure to other members of the community and the owner may find it impossible or uneconomical to charge the community for it. Thus mere existence of consumption externality does not make a good a public good. Moreover, all public goods do not necessarily contain externalities. Take the case of

"pay TV". It is a public good. Additional consumers get it at a zero marginal cost. But it is possible to exclude people from its enjoyment, if they do not pay for it. Thus it has no externalities.³⁵

In a public good both the characteristics of joint consumption and consumption externalities may be present. But the unique characteristic of a "pure public good" or a "polar case" public good, I believe, is that of joint consumption. Joint consumption arises out of creation of a facility or production of a good if more people can consume it without a corresponding reduction in the consumption of those who are already consuming it. But an externality (consumption externality) arises out of one individual's consumption of a facility or a good creating benefits for others which cannot be charged for through the market-place. If a good has only consumption externalities and no joint consumption, it is not a pure public good though it has one of the characteristics of a public good. It may be called a Non-Private Good. Education is an outstanding example of such a good. Such a good will be produced in the private sector but not to a socially optimum level. The modern highly technical society needs a high degree of education if it is to function well. In a pure market supply of education, buyers will only purchase until $MPB = Price$. But MSB will be well above the price because of the presence of external economies in the spread of education. To arrive at a socially optimum allocation of resources, more education should be

purchased. But without government intervention, this extra amount will not be purchased.*

An almost identical kind of argument holds in the case of public health services. Most of the public health services cause consumption externalities. Take, for example, the activity of case finding in tuberculosis control programs and treating the active TB patients in sanatoria. It clearly involves externalities because tuberculosis is a communicable disease. The greater the success in curing and controlling it the lesser are the chances of others contracting it. Thus by a tuberculosis control program it is not only the patients who benefit but others also who may contract tuberculosis in the absence of such a program.

Similarly, take the case of the general disease prevention activities of public health departments. Immunizing a group of people against smallpox, and other contagious and infectious diseases, benefits not only the person who takes inoculations against such diseases but also all others who come in contact with him. There is of course no market way in which these others can be charged, for the benefits obtained, by the person who takes the trouble to be immunized.**

*Services like education and public health of course may not be purchased, if left to pure private market, in a socially optimal amount because of imperfections in the market, such as irrationality and inadequate information, etc.

**A further external economy of public health is that a healthy society is likely to be more productive, with everyone's standard of living raised.

Moreover these externalities also involve joint consumption in the sense that if some additional persons enjoy them that does not mean that the amount of external economies available to those who originally enjoyed them will be reduced.

Many public health activities may satisfy both the characteristics of a public good. Take, for example, the case of Tuberculosis Sanatoria. To a large extent -- unless the capacity limit is reached -- they are equally available to TB patients and hence are "jointly consumed"; and the fact that TB patients are being treated there generates external economies for the community, by reducing its burden of the disease.

Thus public health services in general are a public good. Most of them possess either the one or both the characteristics of a public good and, therefore, government's intervention in their supply is necessary.*

*Musgrave describes another category of goods which, he thinks, should be provided by government. He uses "subsidised low-cost housing", "public furnished school luncheons" and "free education" as some of the examples of such goods. These goods he defines as "merit goods". These goods, unlike public goods, do not entail joint consumption, nor do they have any problems of exclusion. Why then should they be provided through public rather than private enterprise? Musgrave's explanation on this point is not very clear. He states that these goods "are considered so meritorious that their satisfaction is provided for through the public budget, over and above what is provided for through the market and paid for by private buyers... The satisfaction of merit wants, by its very nature, involves interference with consumer preferences".³⁶ In fact, most of the merit goods as defined by Musgrave may involve substantial externalities. This is certainly true of his example of "free education". Alternatively in the case of some goods individual preferences may not lead to individual welfare. This is true of his example of liquor.³⁷

2.3 Increasing Returns to Scale

There is a further case where the production of a good in a socially optimal way requires the intervention of government. This is the case of industries where there are increasing returns to scale or where competition would require a duplication of fixed capital which would result in excessive costs. These conditions hold in the case of some public health services. Consider, for example, the services of water supply and sewage disposal. In their case production process involves decreasing unit costs of production and competition would involve unwieldy duplication of bulky capital goods. They may not be produced optimally by the private sector. Pareto optimality requires that price should be equal to MSC which is generally $=$ MPC. In the case of a decreasing cost industry the cost per unit of production will be falling as the quantity of output is increased. By the well known average and marginal cost relationship it follows that in such a case marginal cost will be below average cost throughout the relevant range of production. If the producer follows marginal cost pricing policy, he will clearly suffer a loss. The outcome is that either he will not produce the good or monopoly will result. Thus government intervention in the supply of such goods and/or services will be required either in the form of complete take-over of production or the control of monopoly through regulating prices and rate of profit etc.³⁸

This chapter leads us to a firm conclusion that government has a most important role to play in providing public health services to the community. In the next chapter we give a general view of benefit-cost analysis as an aid to government decisions and operations in this field. Then in the subsequent chapters we explain the applicability of this theory to a specific public health problem: the control of tuberculosis in Ontario.

FOOTNOTES

¹Eric J. Hansen, The Public Finance Aspects of Health Services in Canada, a study prepared for the Royal Commission on Health Services (Ottawa: Queen's Printer, 1963), p. 2.

²Edward G. McGavarn, "What is Public Health", CJPH, 44 (December, 1953), 441-451.

³WHO, Expert Committee on Public Health Administration: First Report (Geneva, 1952), quoted in Hansen, Health Services in Canada, p. 2.

⁴Ibid.

⁵Royal Commission on Health Services, Report of the Commission (2 Vols.; Ottawa: Queen's Printer, 1964), I, 7.

⁶For a very lucid and detailed exposition of the theory of government intervention in the economy -- based on the concepts of externalities and increasing returns to scale, etc. -- and its historical evolution from Adam Smith onwards, see T. Merritt Brown, Specification and Uses of Econometric Models (Toronto: Macmillan Company of Canada Ltd., 1970), pp. 248-277.

⁷Paul A. Samuelson, "The Pure Theory of Public Expenditure", Review of Economics and Statistics, 36 (November, 1954), 387-389; "Diagrammatic Exposition of a Theory of Public Expenditure", Review of Economics and Statistics, 37 (November, 1955), 350-356; "Aspects of Public Expenditure Theories", Review of Economics and Statistics, 40 (November, 1958), 332-338.

R.A. Musgrave, "The Voluntary Exchange Theory of Public Economy", QJE, 53 (February, 1939), 213-237; H.R. Bowen "The Interpretation of Voting in the Allocation of Resources", QJE, 58 (November, 1943), 27-48.

⁸Samuelson, "Pure Theory", p. 387.

⁹_____, "Diagrammatic Exposition", p. 350.

¹⁰John G. Head, "Public Goods and Public Policy", Public Finance, 17, No. 3 (1962), 197-221.

¹¹James Buchanan, The Demand and Supply of Public Goods (Chicago: Rand McNally and Company, 1968), pp. 34-37.

¹²Ibid.

¹³Ibid., p. 49.

¹⁴Out of these, the first two examples are given in Samuelson, "Diagrammatic Exposition" and the last two are to be found in his "Aspects of Public Expenditure Theories".

¹⁵Stephen Enke, "More on the Misuses of Mathematics in Economics: A Rejoinder", Review of Economics and Statistics, 37 (May, 1955), 131-133; Julius Margolis, "A Comment on the Pure Theory of Public Expenditure", Review of Economics and Statistics, 37 (November, 1955), 347-349; Head, "Public Goods and Public Policy".

¹⁶Samuelson, "Diagrammatic Exposition".

¹⁷Ibid., p. 356

¹⁸Head, "Public Goods and Public Policy", p. 202.

¹⁹Buchanan, Demand and Supply of Public Goods, p. 66.

²⁰Francis M. Bator, "The Anatomy of Market Failure", QJE, 72 (August, 1958), 362 and 365.

²¹See, for example, R.H. Coase, "The Problem of Social Cost", Journal of Law and Economics, 3 (October, 1960); J.M. Buchanan and W.C. Stubblebine, "Externality", Economica, 29 (November, 1962).

²²Some examples which Marshall gave to describe the concept of externalities are to be found in A. Marshall, Principles of Economics (8th ed.; London: Macmillan and Co., 1920), Bk iv, ch. ix.

²³Proof of this assertion can be found at various places in the literature. See, for example, S.K. Nath, A Reappraisal of Welfare Economics (London: Routledge and Kegan Paul, 1969), pp. 63-91.

²⁴Brown, Specification and Uses of Econometric Models, pp. 252-253.

²⁵A.C. Pigou, The Economics of Welfare (London: Macmillan and Co., 1932).

²⁶For a fuller discussion on these methods, see Brown, Specification and Uses of Econometric Models, pp. 252-255.

²⁷The reader interested in this controversy may refer to the articles and books mentioned in footnotes 21, 23 and also to Ralph Turvey, "On Divergence between Social Cost and Private Cost", Economica, 30 (August, 1963).

²⁸Roland N. McKean, Public Spending (New York: McGraw Hill, 1968), p. 65.

²⁹Richard A. Musgrave, The Theory of Public Finance (New York: McGraw Hill, 1959), p. 9.

³⁰Ibid., p. 8.

³¹Richard A. Musgrave, Fiscal Systems (New Haven and London: Yale University Press, 1969), pp. 3-23.

³²Ibid., p. 9.

³³Ibid., p. 7.

³⁴Ibid., p. 10.

³⁵For further discussion on this point see Jesse Burkhead and Jerry Miner, Public Expenditure (Chicago and New York: Aldine-Atherton, 1971), pp. 25-33.

³⁶Musgrave, The Theory of Public Finance, p. 13.

³⁷For a detailed examination of these points see Burkhead and Miner, Public Expenditure, pp. 125-133.

³⁸Governments usually themselves produce the goods and services if their consumption is mandatory; otherwise they tend to leave their production in the private sector but control it to avoid waste and consumer-exploitation. See Brown, Specification and Uses of Econometric Models, pp. 250-252.

CHAPTER III

BENEFIT-COST ANALYSIS: A GENERAL BACKGROUND

1. Benefit-Cost Analysis and the Program Planning and Budgeting System (PPBS)

Benefit-cost analysis is a technique of public-project evaluation and it is gaining more and more prominence in the economic literature. It has a long history going as far back as 1844 when Dupuit wrote his essay, "On the Measurement of Utility of Public Works".¹ However, its more recent history is traced from the beginning of this century especially the mid-1930's when several government departments in the U.S.A., e.g., the Army Corps of Engineers, the Department of Agriculture and the Department of Interior's Bureau of Reclamation, started using it as a measure of project justification especially in the field of water resources. Since then its use has been extended to numerous other fields of government activity.

Economists have become increasingly interested in using, expanding, refining and improving this technique especially since 1965 when the U.S.A. pioneered a new type of budgeting system called the PPBS -- the Program Planning and Budgeting System.² Benefit-cost analysis is an important and integral part of this new system of budgeting. Under this system, "each department must formulate its objectives, weighing the benefits against the costs; must examine alternative means of achieving these objectives; and must shape

its budget request on the basis of this analysis."³ Regarding its adoption in Canada, Mr. Benson, the former finance minister, had the following to say, "Its adoption in Canada is inevitable, not only because of the tremendously increased public expenditures but also because of changes in the balance between functions of those expenditures,..."⁴ PPBS has been an outcome of a quest to develop methods which ensure that large sums of money which are spent by the government every year -- on Education, Public Health, Urban Renewal and Transportation, etc.-- are used in an efficient way.

2. Benefit-Cost Analysis and Profitability Analysis

Benefit-cost analysis, says John Krutilla, "can be characterized as the collection and organization of data relevant by some conceptually meaningful criteria to determine relative preferredness of alternatives..."⁵ We measure systematically all the relevant costs and benefits of the project over its life span and compare them in order to reach a decision about its feasibility and preferredness. A long view of the project is taken in the sense that total costs and benefits are measured whether they occur in near or far future. A wide view of the project is taken in the sense that all benefits and costs whether direct or indirect are taken into account. Externalities and side-effects are considered, and given prominence.⁶

Benefit-cost analysis in this sense is different from, though similar to, profitability analysis in the

private sector.⁷ It has been clearly brought out in the literature that given a system of laissez-faire capitalism with perfect competition, no externalities and no taxes, revenue of a firm from a project measures social benefits from that project and the firm's costs measure the social costs of that project. It is obvious, therefore, that under such a system profits represent the gains that accrue to society from that project.⁸

If any of the above assumptions is violated then there arises discrepancies between social benefits and private benefits on the one side and social costs and private costs on the other. Under such circumstances, if we are to evaluate a project from the social point of view, we cannot depend on the market prices of the inputs and outputs of that project to determine their value to society. We have to adjust these prices (including the price of money, i.e., rate of interest) and where no such prices are available at all (in the case of goods and services which are provided by government free of any direct charge to the consumer) we have to impute them. This basic difference between benefit-cost analysis and profitability analysis has been clearly brought out in the following observation:

Indeed it may be said that one of the principal concerns of cost-benefit analysis is to appraise costs and benefits from a social point of view in cases where these diverge from the pecuniary costs and benefits perceived by the individuals in the market place.⁹

3. The Evaluation Methods

The objective of using benefit-cost analysis for public project selection is to maximize "social welfare" by allocating the scarce resources efficiently. An efficient utilization of resources leads to profit (in this case social gain) which in turn, it can be shown, helps form "the basis of vertical growth by which a society raises itself above a stationary state of subsistence living."¹⁰ Cost-benefit analysis, therefore, attempts to establish criteria on the basis of which investment projects should be selected.

Various algorithms for this purpose have been suggested and used by the analysts. As stated above, benefit-cost analysis and profitability analysis are similar except that in the case of the former we either impute or adjust -- as the case may be -- the input and output prices. Therefore, the methods of project evaluation used here are also similar to those used by the firms in the private sector. These techniques have been described and discussed in detail by many authors.¹¹ Here we will consider only those algorithms which use the discounted values of all the benefits and costs of the project over its life span. Other methods like the "Payback Period", "Proceeds per Dollar of Outlay" and the "Average Income on the Book Value of the Investment", etc., though used by businessmen, can immediately be discarded.¹² One important drawback common to all these methods is that they fail to take proper account of the timing of the benefits and costs of a project. But time here is the essence of

the matter. A dollar's worth of benefits (inflows) received today is not the same thing as a dollar's worth of benefits received a year hence or two years hence. The same holds with respect to costs (outflows). The reasons for this are well explained in the literature and we do not propose to go into them.¹³ But we can make these streams of benefits and costs of a project over its lifetime commensurable by discounting them to the present or to some other common point in time. The measures of project evaluation which use discounting of costs and benefits of a project can broadly be put in two categories: (1) the present value method and (2) the rate of return method. We will briefly consider these methods one by one.

3.1 The Present Value Method

The present value of a single element in a stream of benefits (or costs) is an amount which, if invested today at compound rate of interest = i , will grow to equal that element at time t in the future. It is thus equal to the future (at time t) value of the element divided by $(1+i)^t$. The present value of the stream itself is equal to the sum of the present values of its elements.

A. Net Present Value

One of the important forms in which the present value criterion of project evaluation is used is to calculate the net present value (NPV) of the project concerned. This is done by using the following formula:

$$NPV = \sum_{t=0}^T \frac{B_t - C_t}{(1+i)^t} \quad (3.1)$$

or, alternatively

$$NPV = \sum_{t=0}^T \frac{B_t}{(1+i)^t} - \sum_{t=0}^T \frac{C_t}{(1+i)^t} \quad (3.2)$$

where

NPV = Net present value of the project being considered;

B_t = Benefits from the project in time t ;

C_t = Costs of the project in time t ;

i = An appropriate discount rate*;

T = Life time of the project;

$t=0$, indicates the present time or that common point in time to which the benefits and costs are to be discounted.

Some writers have called this criterion the "discounted cash flow" (commonly abbreviated as the DCF) method of project selection.¹⁴ Cash flow is not identical

*This discount rate, in practice, is assumed to remain constant to facilitate the calculations. But it may vary over time and be i_1 , for year one, i_2 for year 2 and i_3 for year 3 and so on. In that case the above formula will be changed to the following form:

$$NPV = (B_0 - C_0) + \frac{B_1 - C_1}{(1+i_1)} + \frac{B_2 - C_2}{(1+i_1)(1+i_2)} +$$

$$\frac{B_3 - C_3}{(1+i_1)(1+i_2)(1+i_3)} + \dots +$$

$$\frac{B_T - C_T}{(1+i_1)(1+i_2)\dots(1+i_T)}$$

with profit. In this case while calculating C_t , we include all costs like capital outlays, costs of material, labour and transport, etc., but we do not include depreciation charges. They are excluded to avoid double counting. To include them in total costs of the project will mean counting investment outlays twice. In the case of social projects taxes are also excluded from C_t . For social accounting purposes they are transfer payments only and need not be treated as cost.

It has been pointed out earlier (see supra, p. 10) that the relevant concept of the benefits and costs in our study is the marginal one. B_t and C_t in the above equations are, therefore, to be treated as indicating the marginal benefits and marginal costs rather than the total benefits and total costs.*

In order to decide whether a project should be undertaken or not, the recommended accept or reject criterion** is to accept any independent project*** if its NPV $(B-C) > 0$

*It has been explained already (see supra, p. 19) that in our research 1948 is treated as the base line year from which the changes in benefits and costs are measured.

**The same criterion will apply if we are making an ex-post study, as is the case with our dissertation. The question raised, however, will be not whether the project is to be undertaken or not but whether the investment already made has been of economic benefit or not.

***Projects are independent of each other provided any of the projects, if carried out, does not affect the net benefits from the others.

and to reject it if $NPV (B-C) < 0$. On the basis of this criterion, all compatible projects* with $NPV (B-C) > 0$ will be carried out. If the projects are technically incompatible**, the project with the highest $NPV (B-C)$ will be selected as long as its $NPV (B-C) > 0$.

These rules for project selection are based on the assumption that there is no "capital rationing" or "fixed capital budget". If the budget of a government department (or of a firm in the private sector) is limited then the projects are to be ranked in order to select such projects as lead to the optimal use of the limited resources. Obviously, all the projects with $NPV (B-C) > 0$ can not be undertaken because of the limited budget restriction. They also can not be ranked in accordance with their $NPV (B-C)$ values: a project with a higher NPV being given priority over a project with a lower NPV . The $NPV (B-C)$ criterion, "although it gives the correct answer to the simplified problem of choice among mutually inconsistent projects, has an inherent bias in favour of large projects which could lead to a less than optimal mix of investment opportunities."¹⁵

This point can be explained with the help of an example. Suppose there are n projects with the NPV of project 1 being NPV_1 and that of project 2 being NPV_2 and so on. Suppose that $NPV_1 > (NPV_2, NPV_3 \dots, NPV_n)$ because project 1 is a

*Projects are said to be compatible with each other if all of them could technically be carried out simultaneously.

**Projects are incompatible when they cannot be carried out simultaneously for some technical reason. Such projects are also said to be mutually exclusive.

very large project; but $NPV_2 + NPV_3 + \dots + NPV_n > NPV_1$. If capital available can finance either project 1 or all other projects, we will be better off by selecting projects 2, 3 --- and n rather than project 1. The NPV (B-C) criterion, however, would decide in favor of project 1.

To cope with such a situation two methods are suggested in the literature.¹⁶

1. It is suggested that the discount rate used should be successively raised until the number of projects which have positive NPV (B-C) is just enough to exhaust the budget. Under these circumstances there will be no need for ranking.

This suggested method has been considered and it has been shown that, "it is not always correct to select projects, to fit a given fixed investment budget, by raising the discount rate until sufficiently few have a positive present value."¹⁷ (Italics mine.)

2. The alternative method is not to raise the selected discount rate but to select those projects which have the highest NPV per dollar of investment expenditure till the budget is exhausted.*

*This is equivalent to what Chenery has called the social marginal product (SMP) of capital criterion.¹⁸ The SMP of a project is the "rate of present value of net benefit per dollar of capital cost. It applies where capital is a constraining factor on a budget... But while focussing on a rate on capital, it differs from the rate of return in the crucial respect that it requires an interest rate to be specified for the computation of present value of net benefit. Thus the SMP is one of a family of present value criteria, while the rate of return is not."¹⁹

This method is believed to be the most generally valid method of ranking investment projects.²⁰

The budget constraint as discussed above usually refers to an investment budget and not to a total-cost budget including investment as well as operating expenses for future years. We can argue that operating and maintenance costs, etc., may be financed out of the revenues generated from the benefits which are captured through either the sale of output of the project or taxation* directly related to the project.²¹ In fact in the case of social projects, like the one under study, budgetary constraints of any type usually are not very important. We can reasonably assume an unlimited supply of funds for such a project.

It will be worthwhile to quote Otto Eckstein on the question of constraints. He observes that, "constraints are rarely an accurate description of an institutional reality. Budgets are not rigidly fixed except over very short periods - and even then there can be supplemental appropriations. Financial requirements, e.g., that an operation be self-liquidating, are rarely followed, if circumstances change. Particularly if a constraint severely interferes with the achievement of economic welfare, the constraint is likely to give way".²²

Moreover, ours is an ex-post study and we are interested in finding out whether the funds spent on this

*Sometimes the group of people to benefit most from a project can be specially taxed to cover expenses of the project. An example may be the farmers who get water from a dam for irrigation.

project were economically an efficient investment. We will, therefore, assume that the resources for the project were freely available. Our aim in this study is to find out whether in this particular case (i.e., TCP in Ontario from 1948-1966) the NPV (B-C) was positive or not.

What is the appropriate rate of discount i , to be used in (3.1) or (3.2) above? This is the subject of still an unresolved controversy in the profession. We have dealt with it, at considerable length, in "Appendix A".

B. Benefit-Cost Ratio

Another variation of the present value criterion is to calculate the benefit-cost ratio for the project concerned, rather than its NPV (B-C).

The benefit-cost ratio for a project can be defined by the following equation:

$$B/C = \sum_{t=0}^T \frac{B_t}{(1-i)^t} \div \sum_{t=0}^T \frac{C_t}{(1-i)^t} \quad (3.3)$$

where

B/C = Benefit-cost ratio of the project concerned and all other variables are the same as defined in equation (3.1) or (3.2)

This measure of project selection has been used quite frequently in benefit-cost studies and its use has been recommended in the literature.²³ In this case the decision algorithm, if there is no capital rationing, is to carry out all independent and compatible projects for which $B/C > 1$. If

the projects are mutually exclusive*, we should select a project with the highest B/C.

This criterion does not bias selection in favour, unlike the NPV criterion (see supra, p. 56), of large over small projects. It can be used as the basis for ranking of projects when the budget is limited. It should, however, be pointed out in this context that B/C is not the same thing as the net worth per dollar of investment or the SMP (see supra, p. 57). In the case of B/C, the denominator C covers all costs, capital as well as operating. The SMP criterion takes account of only the capital costs.

If the budget constraint is in effect a constraint on only the investment costs**, the SMP criterion should be preferred to the B/C criterion (see below). If the budget constraint is applicable to total-cost budget, the B/C criterion and the NPV per dollar cost criterion will give equivalent ranking to the projects.***

*I.e., one project precludes the other or is incompatible with the other.

**It has been argued above (p. 58) that this may be the case most of the time.

$$***\text{NPV per dollar cost} = \frac{\sum_{t=0}^T B_t - \sum_{t=0}^T C_t}{\sum_{t=0}^T C_t} = \frac{\sum_{t=0}^T B_t}{\sum_{t=0}^T C_t} - 1 \quad (3.4)$$

where

$$\sum_{t=0}^T B_t = \sum_{t=0}^T \frac{B_t}{(1+i)^t} ;$$

$$\sum_{t=0}^T C_t = \sum_{t=0}^T \frac{C_t}{(1+i)^t} ;$$

B_t , C_t , T and i have the same meaning as in

(3.1)

The B/C criterion, however, has one main defect. It is that by transferring benefits or costs between the numerator and the denominator, the ratio and hence the decision on the project can be significantly altered. Suppose the present value of the benefits received from project A is \$300 and the present value of its cost is \$150. B/C of project A in this case is $\frac{300}{150} = 2.0$. Suppose we now treat \$50 of the cost as the present value of disbenefits and subtract them from benefits. B/C of project A now becomes $\frac{250}{100} = 2.5$.*

It was on this ground that some of the practitioners of benefit-cost analysis participating in a meeting of experts on cost-benefit analysis of social projects opposed the use of B/C as a criterion of project selection.** They, however, agreed that the use of B/C criterion will be legitimate if either of the following conditions could be fulfilled:

1. The numerator or the denominator was given as a constant.
2. Rules could be devised for limiting the transference of items from the cost to the benefit side of the ratio, or vice versa.²⁴

In view of the above, given that there is no necessity for ranking the projects, NPV (B-C) may be preferable to B/C as a criterion of project selection.²⁵ Take, for

*Theoretically, by treating all the costs of the project as disbenefits, we could make B/C of A = ∞

**This meeting was held from September 27 to October 2, 1965 in Rennes, France. It was called by the United Nations Research Institute for Social Development in co-operation with some other agencies and it was chaired by J. Tinbergen.

example, a situation where there is no capital rationing but we have to decide between two mutually exclusive (incompatible) projects A and B. For the sake of simplicity, let us assume that all costs of each of these projects occur in t_0 and all their benefits are received in t_1 ; and that funds can be obtained at 10 per cent rate of interest which will be used as the rate of discount. Suppose that the costs and benefits of these projects are as given in table 3.1 below. It also gives benefit-cost ratios and NPV (B-C) for each of these projects.

TABLE 3.1
COSTS AND BENEFITS OF PROJECTS A & B

Project	Costs in t_0	Benefits in t_1 *	B/C	NPV (B-C)
	(\$)	(\$)		(\$)
A	6,000	7,909	1.318	1,909
B	14,400	18,182	1.263	3,782

*Discounted to t_0 by 1.10

On the basis of B/C criterion project A will be preferable, but if we apply NPV (B-C), project B will be preferable. The B/C criterion tends to favour a smaller project with a higher B/C but lower absolute net benefits. Given our assumptions of no capital rationing and incompatibility of A and B, we would be better off by opting for the larger

project. In this case the NPV criterion, as against the B/C, helps us make the right choice and, therefore, should be the preferred criterion of project selection.

The B/C criterion, however, is specially useful when both costs and benefits cannot be measured in the same units (usually monetary units). We usually can put some dollar values on costs but it becomes, at times, very difficult to translate benefits into dollar terms. In such cases, however, we are no longer dealing with benefit-cost analysis but with cost-effectiveness (see supra, p. 9).

3.2 Rate of Return Method*

This is the third method of project evaluation and it has often been used in benefit-cost analysis. Average (or internal) rate of return can be defined as that rate of discount which will make the present value of costs of a project equal to the present value of its benefits. In other words, it is that rate of discount which satisfies the following equation:

$$\sum_{t=0}^T \frac{B_t}{(1+r)^t} = \sum_{t=0}^T \frac{C_t}{(1+r)^t} \quad (3.5)$$

or

$$\sum_{t=0}^T \frac{B_t}{(1+r)^t} - \sum_{t=0}^T \frac{C_t}{(1+r)^t} = \text{NPV (B-C)} = 0 \quad (3.6)$$

*Terms like the yield on investment, average rate of return, internal rate of return and the marginal efficiency of capital (when only capital costs are being taken into consideration) are also used for this expression.

Here all the variables except r are the familiar ones. They have the same meaning as in equation (3.1). r is the rate of return and will be found by iterations using either Newton's iterative method or compound interest tables.

If the decision to be taken is an "accept or reject" type of decision, on the basis of this criterion an independent project is to be accepted if its rate of return is higher than a certain minimum acceptable rate of discount (usually called the cut-off rate). If there is no capital rationing, all the projects fulfilling the above condition should be carried out. If the projects are mutually exclusive or the total investment budget is limited and thus the projects are to be arranged in order of priority then the project with the highest rate of return will be given the highest priority and the project with the rate of return next to it will be given the second place in the list of priorities. The whole list can be arranged in this way till, in case of a limited budget situation, all the available funds are exhausted.

The use of rate of return criterion for project selection was highly recommended in the 1950's, especially in the private sector.²⁶ But its use has recently been questioned and it has been argued rightly that it is only under exceptional circumstances (viz., a perfectly competitive market) that this criterion provides us with an optimal choice among investment alternatives.²⁷

Various shortcomings in using the rate of return criterion have been pointed out in the literature. In comparing

the mutually exclusive projects, for example, it will favour a small project with a higher rate of return (but a smaller NPV) as against a large project with a smaller rate of return (but a larger NPV).^{*} Such an outcome, given no capital rationing and hence no need for ranking, does not lead to an efficient utilization of resources (cf., p. 61-63).

There is a possibility that in the case of some projects, we may not be able to calculate any real value for the rate of return. Consider the example, given by Hirshleifer, of a project with a net benefit stream of -1, 3 and $-2\frac{1}{2}$ in periods 0, 1 and 2 respectively.²⁸ Using equation (3.5) or (3.6) to calculate the rate of return on this project, we end up with the following:

$$2i^2 - 2i + 1 = 0 \quad (3.7)$$

Roots for this equation will turn out to be:^{*}

$$\frac{2 \pm \sqrt{4 - 8}}{4}$$

Clearly, this project has no real internal rate of return and thus on the basis of the rate of return criterion it is impossible to take any unambiguous decision on this

^{*}Projects when ranked according to their NPV (B-C) at a given rate of discount are not always in the same order as when ranked according to the rate of return criterion.

^{**}For a quadratic equation, $ax^2 + bx + c = 0$, the solution is given by the following formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

project. But if we use the NPV (B-C) criterion the project is to be rejected because it will have a negative NPV (B-C) "throughout the relevant range" of discount rates.²⁹

Similarly, it can be shown that there may be projects for which the rate of return does not have an unique value. In fact it is only in the case of "conventional investments"* that we will have one and only one rate of return. In all other (non-conventional) projects we may have one or more than one or even an indeterminate number of rates of return.³⁰

Non-conventional flows may result from the fact that in some projects major items of equipment have to be replaced quite frequently, say after an interval of every 3 or 5 years. In such cases we may have negative net benefits whenever the replacements take place.

One advantage which is often claimed for yield criterion as compared to the present value method (i.e., the NPV or B/C) is that for its use we do not have to make a choice of a discount rate. Such a choice, which in most cases will be a subjective value judgement, is very essential for the NPV (B-C) or the B/C method. But this argument is true only if we are concerned with ranking the projects. If we are to decide whether an independent project should be undertaken or not, we will have to compare its rate of return with some minimum acceptable discount rate to reach

*Conventional investments are defined as those investments which have one or more periods of net outlays followed by one or more periods of proceeds.

a decision. Thus, while analyzing single case studies like ours, we cannot evade the issue of making a choice of an appropriate rate of discount to be used in benefit-cost analysis.

From our brief review of the various methods used for project selection, we could arrive at the following conclusion: (1) As a general rule, the net present value method seems to be of general applicability and hence better than the rate of return method. (2) Of the two variations of the net present value method, the NPV seems to be of general applicability and hence the better one if there are no budgetary constraints and, therefore, no ranking of the projects is involved. (3) If there has to be ranking of the projects, the SMP or the B/C will be preferable to the NPV depending on the nature of the budgetary constraint.

As far as our study is concerned, we assume no budgetary constraints. It is a single case study and its main aim is to find out if the use of resources in the TCP in Ontario from 1948 to 1966 has been efficient or not. In view of the above survey the preferred method for our study should be the NPV (B-C). The results of our research, however, are reported for all the three criteria.

4. Efficiency and Non-Efficiency Objectives

Efficiency in the context of benefit-cost analysis is used in the sense of additions made to national product.³¹ It follows from the above discussion that benefit-cost

analysis is used to select those social projects, given the expenditure constraints, which make the maximum additions to national product.

It has been pointed out that the objective of undertaking a public investment is to increase social welfare, and economic efficiency can be but only one variable in the social welfare function. Other equally important variables can be redistribution of income to classes or to regions, national defence and so on. Emphasis on economic efficiency to the exclusion of all other non-efficiency considerations has been challenged. Arthur Maass has called it "the major limitation of benefit-cost analysis as it has been applied to public investments in the United States..."³² He blames the new welfare economics for this lacuna in benefit-cost analysis:

The federal bureaucrats, it should be noted, were not acting in a vacuum, they were reflecting the doctrines of the new welfare economics which focused entirely on economic efficiency. Non-efficiency considerations have been held to be outside the domain of the welfare economist. They have been called by such loaded names as inefficient, value-laden, altruistic, merit wants, uneconomical.³³

He suggests that a trade-off ratio between efficiency and one most important non-efficiency objective (and this according to him will be redistribution of income most of the time) should be determined for any government program. This, he thinks, can be done through political process. Once it is done the planner can attach relative weights to efficiency and non-efficiency objectives and choose on that basis from the alternatives available to him. Other economists

also have made a case for the integration of efficiency and equity criteria.³⁴

We assume that it will be better to keep allocation and distribution separate as much as possible.³⁵ Income redistribution in itself is a very important and over-all problem faced by every modern society. It may be in the best interest of society, we believe, to make the most efficient use of its resources and to achieve other objectives like equity by fiscal and other policies like minimum-wage legislation, etc. Such a policy may enable society to redistribute a larger aggregate product.³⁶ And benefit-cost analysis, applied to individual projects, assists us in maximizing the national product given resources and technology.

Indeed the TCP in Ontario which is to be studied in this dissertation serves the twin objectives of efficiency and equitable distribution of income. Expenditure on tuberculosis control to a great extent is an investment in human capital and hence to a large measure in the efficiency of the economy. More healthy human resources in Ontario are likely to enhance the efficiency of the economic apparatus. At the same time, the objective of redistributing income more equitably among the various groups in the economy is achieved because it is society rather than the individual who is stricken which bears the major part of the cost of this program. As we will see later (Chapter V) funds for this program come largely from the provincial and federal governments.

The next question now is how benefit-cost analysis

is to be applied specifically in the case of public health programs. Methodology of benefit-cost analysis for this purpose is explained in the next chapter. This is done by describing it in the context of a specific public health program: the TCP in Ontario. But it can be applied to study the investment worth of various other public health programs, especially programs where the main objective is to control some disease.

FOOTNOTES

¹J. Dupuit, "On the Measurement of Utility of Public Works:", English translation, in International Economic Papers, No. 2 (London: Macmillan, 1952).

²For a discussion on various aspects of PPBS, see "PPBS Symposium", Public Administration Review, 26 (December, 1966).

³Dorothy P. Rice, "Measurement and Application of Illness Costs", Public Health Reports, 84 (February, 1969), 98.

⁴E.J. Benson, "Budget Breakthrough: Adoption of PPB", Canadian Tax Journal, 16 (May-June, 1968), 161-167.

⁵John V. Krutilla, "Welfare Aspects of Benefit-Cost Analysis", JPE, 69, No. 3 (1961), 226.

⁶A.R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey", in Surveys of Economic Theory, Vol. III: Resource Allocation (Toronto: Macmillan for the American Economic Association and The Royal Economic Society, 1966), p. 155.

⁷A brief explanation of the main differences between cost-benefit analysis and profitability analysis by a firm can be found in Ian M.D. Little and James A. Mirrlees, Manual of Industrial Project Analysis in Developing Countries, Vol. II: Social Cost-Benefit Analysis (Paris: OECD, 1969) pp. 20-21.

⁸Ibid., pp. 23-29.

⁹Arnold C. Harberger, "Survey of Literature on Cost-Benefit Analysis for Industrial Project Evaluation" (a paper prepared for the Inter-Regional Symposium in Industrial Project Evaluation, Prague, Chekoslovakia, October, 1965), Mimeographed.

¹⁰T. Merritt Brown, Specification and Uses of Econometric Models (Toronto: Macmillan Company of Canada Ltd., 1970), p. 82.

¹¹Harold Bierman Jr. and Seymour Smidt, The Capital Budgeting Decision (2nd edition, New York: The Macmillan Company, 1968); Brown, Specification and Uses of Econometric Models, pp. 117-123; Development Centre of the OECD,

Manual of Industrial Project Analysis in Developing Countries, (2 Vols.; Paris: OECD, 1968), I, 109-142; Otto Eckstein, "A Survey of the Theory of Public Expenditure Criteria", in Public Finances: Needs, Sources and Utilization, ed. by James M. Buchanan (Princeton: Princeton University Press, 1961); J. Hirschleifer, J.C. de Haven and J.W. Milliman, Water Supply: Economics, Technology and Policy (Chicago: University of Chicago Press, 1960) chapter VII; J. Lesourne, Economic Analysis and Industrial Management (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963), Chapters II and XIII; Friedrich and Vera Lutz, The Theory of Investment of the Firm (Princeton: Princeton University Press, 1951), pp. 16-48; P. Massé, Optimal Investment Decisions (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962), Chapter I; Roland N. McKean, Efficiency in Government Through Systems Analysis, with Emphasis on Water Resource Development (New York: John Wiley and Sons, 1958), pp. 25-150.

¹²A brief description of these methods and a discussion on them can be found in Bierman and Smidt, The Capital Budgeting Decision, pp. 21-25.

¹³Ibid., pp. 61-64; Brown, Specification and Uses of Econometric Models, pp. 117-118.

¹⁴Development Centre of the OECD, Manual, I, p. 116.

¹⁵Jesse Burkhead and Jerry Miner, Public Expenditure (Chicago and New York: Aldine-Atherton, 1971), p. 220.

¹⁶Development Centre of the OECD, Manual, I, p. 118.

¹⁷Ibid., p. 119.

¹⁸H.B. Chenery, "The Application of Investment Criteria", QJE, 67 (February, 1953), 76-96.

¹⁹Eckstein, "Survey", p. 461.

²⁰OECD, Manual, I, p. 120.

²¹For further discussion on this point, see McKean, Efficiency, pp. 114-116.

²²Eckstein, "Survey", p. 452.

²³W.R.D. Sewell, et al., Guide to Benefit-Cost Analysis (Ottawa: Queen's Printer, 1965), pp. 12-13.

²⁴United Nations Research Institute for Social Development, Cost-Benefit Analysis of Social Projects, Report of a meeting of experts (Geneva: April 1966), p. 18.

²⁵For a detailed discussion on B/C criterion, see McKean, Efficiency, pp. 107-118.

²⁶See, for example, E.L. Grant and W. Grant Ireson, Principles of Engineering Economy (3rd edition, New York: Ronald Press Company, 1950), chapter 18; J.G. McLean, "How to Evaluate New Capital Investments", Harvard Business Review, 36, No. 6.

²⁷J. Hirshleifer, "On the Theory of Optimal Investment Decision", JPE, (August, 1958), 329-352; Harberger, "Survey", M.S. Feldstein and J.S. Fleming, "The Problem of Time-Stream Evaluation: Present Value versus Internal Rate of Return Rules", Bulletin of the Oxford University Institute of Statistics, 26 (February, 1964), 79-85.

²⁸Hirshleifer, "Optimal Investment Decision", p. 349.

²⁹Ibid.

³⁰Ibid., 348-349; Harberger, "Survey"; Bierman and Smidt, The Capital Budgeting Decision, pp. 44-47.

³¹Arthur Maass, "Benefit-Cost Analysis: Its Relevance to Public Investment Decisions", QJE, (May, 1966), 208-226; Aaron Wildavsky, "The Political Economy of Efficiency: Cost-Benefit Analysis, Systems Analysis, and Program Budgeting", Public Administration Review, 26 (December, 1966), pp. 292-310.

³²Maass, "Benefit-Cost Analysis", p. 208.

³³Ibid., p. 213.

³⁴Eckstein, "Survey"; A.M. Freiman, "Income Distribution and Public Investment", AER 57 (June, 1967), 495-508; Stephen A. Marglin, Public Investment Criteria (London: George Allen and Unwin Ltd., 1967).

³⁵See Richard A. Musgrave, "Cost-Benefit Analysis and the Theory of Public Finance", Journal of Economic Literature, 7 (September, 1969), 803-805.

³⁶Usually redistributing, equitably, smaller national product hampers economic growth via adversely affecting aggregate savings and investment in the economy. In the context of deciding goals of economic policy, especially in under-developed countries, there has been a good deal of discussion on this point, i.e., whether equitable distribution of income would accelerate or retard economic growth.

CHAPTER IV

BENEFIT-COST ANALYSIS OF TUBERCULOSIS CONTROL PROGRAM: METHODOLOGY

This chapter explains how we measure the benefits and costs of the tuberculosis control program (TCP) in Ontario. It outlines the methodology used and discusses the assumptions made. The data used and the results obtained are reported in the next chapter.

In calculating the benefits and costs of the project, benefits are defined as all advantageous effects to society. Prevention or cure of a disease has tremendous humane value to the beneficiary and society. It gives increased psychic income to friends and relatives. But we cannot calculate such benefits -- though we must always keep them upper-most in our minds -- and no attempt will be made to measure them. What we can measure from an economic point of view is only the increase in production brought about as a result of success of the project. This approach will impart a downward bias to the estimated benefits, similar to that in measuring social returns to investment in education. The basic philosophy adopted in this dissertation is to estimate benefits conservatively and to opt for upward biased cost estimates if a choice had to be made among the alternative estimates. This approach will ensure that the true NPV (B-C) or B/C should be at least as large as the estimate resulting from our research.

It will be recalled that we are interested in

estimating the marginal benefits* of the program over the period 1948-1966 inclusive (see supra, pp. 9-10). They are determined by measuring and summing the benefits, for each year, derived from:¹

1. Reduced Deaths;
2. Reduced Disability -- disability being defined as sickness sufficient to cause absence from work; and
3. Reduced Debility -- debility being defined as sickness that does not cause absenteeism but reduces worker's productivity on the job.

1. Benefits of the Program

These benefits will symbolically be represented by B_1 , B_2 and B_3 .

1.1 Benefits from Reduced Deaths -- B_1

Benefits from reduced deaths (or B_1) will be equal to additions made to national product (in dollar terms) as a result of net additions to the labour force made possible by the reduced number of deaths each year**. These benefits will be measured by the following formula:

$$B_1 = \sum_{t=t_0}^T \left[\sum_{n=1}^{70+} (V_{n,m} \cdot D_{n,m})_t + \sum_{n=1}^{70+} (V_{n,f} \cdot D_{n,f})_t \right] \cdot \frac{1}{(1+i)^{t-t_0}} \quad (4.1)$$

*The reader may be reminded that by marginal benefits we mean any incremental or decremental change in benefits (cf., ch. I, p. 9).

**The rates of employment and labour force participation are relevant for these calculations. They are dealt with later in the chapter (see infra, pp. 89-91).

where

$V_{n,m}$ = Present value of life-time earnings of a male of age n years;

$D_{n,m}$ = Reduction in the number of tuberculosis deaths in case of males of age n years, for the total Ontario population;

$V_{n,f}$ = Present value of life-time earnings of a female of age n years;

$D_{n,f}$ = Reduction in the number of tuberculosis deaths in case of females of age n years, for the total Ontario population;

t_0 = Base year chosen for making calculations. In the case of our project it is 1948;

T = Terminal year; for this analysis it is 1966;

i = An appropriate discount rate;

l = means age 0-1, 2 means age 1-2; etc.; and so on;

A. Reduction in the Number of Tuberculosis Deaths -- D_n

It still remains to be explained how we measure D_n and V_n for each sex. As far as D_n is concerned, the method is explained below. As exactly the same method is used to determine both $D_{n,m}$ and $D_{n,f}$, its description is given in general terms without making any specific reference to the sex of tuberculosis deaths. Separate calculations, however, are made for each sex.

We have annual data on the actual number of tuberculosis deaths from 1948 to 1966. For each year the data are given by several age groups. For similar age groups we make yearly projections of the number of deaths which would have occurred had the TCP been at the pre-1948 level. The difference between these two figures for each age group in

each year gives the reduction in the number of deaths (each year) which can be attributed to the success of the tuberculosis control program in Ontario. To project the number of tuberculosis deaths by age, it is assumed that in the absence of the "extended tuberculosis control program" the death rate for each age group would have remained constant at a level given by the average of death rates for that age group in 1945 to 1947. Then the projected number of deaths by age in each year from 1948 to 1966 is obtained by the following formula:

$$qD_{x,t}^1 = qN_{x,t} \cdot qM_x^1 \quad (4.2)$$

where

$qD_{x,t}^1$ = Total number of deaths between ages x and $x+q$ in time t due to cause 1 (in our case it is tuberculosis);

$qN_{x,t}$ = Total population in Ontario between ages x and $x+q$ in time t ;

qM_x^1 = Assumed constant death rate between ages x and $x+q$ due to cause 1.*

It is to be noted that qM_x^1 is assumed to remain constant at the average level of such rates in 1945 to 1947 rather than at its level in 1947 alone: the year preceding 1948 when the TCP was launched. This assumption is made to mitigate the effect of any abnormal tuberculosis deaths which might have occurred in 1947. It could be argued that the

*A useful description of the various types of mortality rates can be found in Mortimer Spiegelman, Introduction to Demography (2nd ed., Cambridge, Mass.: Harvard University Press, 1969), pp. 81-115.

average of rates in 1946 to 1948 should be used. 1948 is, however, excluded because in that year some portion of the benefits resulting from the TCP must have been realized. The comparison in our study is between benefits with and without the program.

There are other methods of projection which could be used for this purpose. One of them is to fit a trend to mortality rates for the past seven or eight years and extrapolate for the immediate future and then to multiply these projected rates by the population for the corresponding years. It is quite commonly used for forecasting the course of diseases. It was used in 1958 by Dublin* to project the total number of deaths from tuberculosis in the United States in 1975.² We are interested in the projections of tuberculosis deaths by age and sex. We looked at the age-specific death rates from 1941 to 1947.³ There was no clearly discernible trend. On the contrary there were wide fluctuations in these rates especially up to 1945. Afterwards they seemed to more or less settle down. We, therefore, decided that our method will give more reliable results than the trend-fitting one.

Another method that could be used is given by Feldmann.** He projected the total number of tuberculosis deaths in the United States in 1977 by using infection rate

*Dr. Dublin was consultant on health and welfare to the Institute of Life Insurance, New York.

**Dr. Feldmann was medical director, National Tuberculosis Association, New York.

and the ratios of new tuberculous cases to infection and of deaths to tuberculous cases in the country.⁴ But unfortunately we do not have reliable data, especially on infection rates* and prevalence of tuberculous cases in Ontario, to make use of Feldmann's method. This paucity of reliable data is felt all the more when we require them by age and sex. Feldmann himself was confronted with a lack-of-data problem. He made some heroic assumptions with the result that he himself was surprised by the projections which he obtained. He admitted that his figure was too high. His attempt, he said, "was an exercise in theory." His "figures", he added, "are not to be taken as predictions, but only as an instance of the kinds of analysis which might be possible if good reliable data were at hand."⁵

B. Present Value of Life-Time Earnings -- V_n

V_n (representing either $V_{n,m}$ or $V_{n,f}$) signifies the output which an average person of age n would add to national product, if his life were saved from premature death. His annual earnings do not give a proper measure of his contribution to national product because once a person's life is saved he works for a number of years until he dies from some other cause, or retires. So we have to find the economic value of a life saved. For this purpose there are no values given by the market. Human beings are not bought and sold. Slave

*Infection rates are measured by tuberculin conversion rates. A negative tuberculin test indicates that the person has not been infected with tuberculosis.

markets have disappeared from the world. And as Rolph and Break have put it: "One freedom is universally denied 'free' people, they may not sell themselves to others."⁶ We can argue that "life insurance purchases" could be used as a surrogate for it. But a person buys life insurance largely out of his concern for his family. It does not reflect the economic value of his life to himself or to society.⁷ As far as pure economic value of a person's life to society in any particular year is concerned, it will be found by calculating the present value of his or her life-time earnings in that year. The following formula will be used for this purpose:⁸

$$V_{a,t} = \sum_{n=a}^K \left[Y_{n,t} \cdot P_{n,t} \cdot S_{a,n,t} \cdot v^{n-a} \right] \quad (4.3)$$

where

$V_{a,t}$ = Present value of life-time earnings of a person aged a years in time t ;

$Y_{n,t}$ = Average earnings of a person aged n years in time t ;

$P_{n,t}$ = Participation rate in the labour force of a person aged n or the probability that a person aged n will be in the labour force in time t ;

$S_{a,n,t}$ = Probability of an individual of a years of age surviving to age n years in time t ;

$v = \frac{1}{(1+i)}$, where i is an appropriate rate of discount;

K = the age at which an individual's earnings are assumed to cease. In our case it has been assumed to be 75. Only very few people will be in the labour force after age 75. But up to 75, we can reasonably assume, most of the people work in one form or the other and have some earnings. Their

earnings towards the later part, especially after 65 years of age, though, will be at a much lower rate than what they were during their prime working age.*

From formula (4.1) it is clear that we need two sets of calculations for the present value of life-time earnings for each year from 1948 to 1966: one for men and the other for women. It is necessary because Y_{n_t} , P_{n_t} , and S_{a,n_t} values change according to both age and sex. For example, labour force participation rates (for all ages) are usually lower for females than for males. Similarly Y_{n_t} is larger for men than for women.

Attempts to quantify the economic value of human life are not new or of recent origin.** Such efforts have been made since the 17th century when Sir William Petty calculated the economic value of a person's life.⁹ Recently, however, the above approach to calculating the economic value of human life has been challenged by Schelling.¹⁰ His argu-

*Formula (4.3) does not include employment rate which obviously is relevant for the calculations. This point, however, has been dealt later in the chapter (see infra, p. 89-90).

**It may be pointed out by some that it is scandalous or repugnant to place value on human life. It is sacred and invaluable. No material measure can be attached to it. Individuals and society, however, often do take decisions which attach value to human life. Jacques Thedie and Claude Abraham sum up the situation beautifully in "Economic Aspects of Road Accidents", Traffic Engineering and Control, 2 (February, 1961), 590. They observe that "A cross-road is laid out, but a sharp turn remains. Some hospitals are built. Why not more? Certain sums are spent on medical research. Why not larger or smaller amounts? Each of these decisions attributes unconsciously in each case a value to human life and suffering!" It follows from this that it will be preferable to make this valuation more conscious and systematic, whenever it is required for policy decisions.

ment is that the government programs affecting mortality (like the TCP in Ontario) are aimed at reducing the statistical probabilities of death in a group of persons. Accordingly, the value of human life is best measured by what a person, whose life is affected, or his family will pay to reduce the probability of his death. Schelling recommends that a representative sample of the affected group should be intensively interviewed and an estimate of the value of life be made from it. His approach has been severely criticised, mainly on two grounds: (1) in spite of all the methods suggested by Schelling to overcome the difficulties inherent in his suggested "intensive interview technique", it is not expected to work operationally and give reliable results; (2) the value which an individual puts on his own life will not determine his value to society.¹¹

We do not find any viable alternative to the "present value of an individual's life-time earnings" approach to estimate the economic worth of a person's life to society; hence this is the approach that is used in this study.

C. Assumptions and Some Points of Clarification

Even among writers who have used this approach, every one gets different values depending on the nature and quality of the data used and the types of assumptions made. Our assumptions and their validity are described below.

(a) Earnings Versus Per Capita or Per Worker Product

It is assumed that earnings adequately represent the value of a person's marginal productivity and hence his

contribution to national product.* It is possible that when labour supply increases as a result of reduced deaths -- other factors remaining constant -- marginal productivity of labour falls. This is a real problem in most of the underdeveloped countries especially in the agricultural sector where there is already "under-employment" and "dis-guised unemployment". It may be assumed that there is no such problem in Ontario. The number of those whose lives are saved as a result of the TCP is so small as compared to the total labour force in the province that it will not affect the labour's marginal productivity very significantly. Moreover, one of the facts of the Canadian economy brought out by T.M. Brown in one of his studies is that, "the Canadian economy as a whole is subject to increasing returns to labour and capital, and that we are still below the optimum proportionality of labour and reproducible capital relative to our land and natural resources."¹² What holds true for Canada will presumably be true for Ontario.

Cross-sectional earnings data are used in our study (see infra, pp. 118-122). It is assumed that a person who was say 40 years old in 1948 earned in 1949 as much as a person of 41 years old in 1948 and in 1950 his earnings were equal to those of a person who was 42 years old in 1948 and so on. But in a growing economy like that of Canada every

*This assumption implies that there are no imperfections in the product and labour markets, otherwise the earnings, as is well known in the literature, will not give a proper estimate of the value of the marginal product of a person.

individual will expect an upward trend in his earnings superimposed on the cross-sectional pattern given for any particular year. This vital fact is taken into account in our calculations by calculating the real rate of growth in average annual earnings and adjusting the V_n values accordingly (see infra, pp. 123-125).

Another point which deserves consideration here is that in some studies the net domestic product per worker (rather than average annual earnings) has been used as a measure of a worker's productivity. For instance, Reynolds and the National Planning Association in the U.S.A. have used this approach to labour productivity.¹³

Fein, while discussing Reynold's study, points out rightly the basic defect inherent in it. He observes:

In a sense, this approach asserts that all of the national product (income) and, therefore, any gains in national product are attributable to labour rather than to some combination of joint factors of production, land, labour, capital, etc. Although it may, indeed, be true that if there were no labour there would be no product, it is equally true that if there were no capital there would be very little product.¹⁴

(b) Value of Household Services

A problem arises with respect to putting a dollar value on the work of a housewife. Many women do not work in the market. Even those who work usually also keep the household. But the value of housekeeping services is not included in calculating the national income. And on this basis, some writers have argued that a housewife's services should be ignored in measuring the present value of life-time earnings

of women. Selma Mushkin first expressed this opinion.¹⁵ It was later defended by Fein in the following words:

...to impute money values to those services which do not enter the money market would raise as many questions as it answers. Where would we draw the line? We, all of us, perform many services for ourselves and others that could be purchased. Should we impute a money value to all these services - e.g. shining shoes, changing a fuse, mowing the lawn, baking a cake?¹⁶

Not to impute money value to odd jobs which everyone of us does will not result in a large under-estimation of the benefits of a program. This, however, will not be the case if we fail to put dollar value on a housewife's work. The cost of paying in the market for the former services is relatively small, while the cost of replacing a housewife's services in the market (for example, when she is sick) becomes a very large expense -- of the order of \$250 per month.* It is not necessary that we should follow an approach consistent with national income accounting. We are interested in measuring the benefits and costs of a particular project and this is not the same as measuring the net flow of marketed goods and services in the economy, i.e., estimating the GNP.¹⁷ An estimated value of a housewife's work, therefore, should be taken into account in our calculations.

But how to arrive at such an estimate? For this purpose two approaches have been suggested in the literature:

1. Estimate the opportunity cost - i.e., what a housewife would earn in paid jobs. This provides a high estimate of the worth of her services to society. From a purely economic point of view the high value of a housewife's work should be what she could earn by working outside in the market.

*This figure is just an example. The actual data used in the calculations are given on page 127, table 5.4.

2. Replacement cost - i.e., the cost of a housekeeper could be used. This will give a low value of a housewife's work.*

We shall use the second approach because it gives the conservative estimate, and also because it gives a precise measure of the market evaluation of housekeeping services. This figure plus the age-specific average earnings of a female will give her total earnings by age, i.e., $Y_{n,f}$.

(c) Value of Consumption

Another question to which we must now turn is whether the average earnings of a person of age $n(y_n)$ should be taken as his gross earnings, or as net of his consumption. There is a controversy on this point. Both concepts are used. For example, Fein, Rice and other researchers make no deductions for a person's consumption.¹⁸ On the other hand, Reynold uses income data net of consumption, though he does not give any reasons for it.¹⁹ Waaler** justifies net-of-consumption approach in the following words:

At any age a person will have a future expected production and a future expected consumption, and the difference will be his future net expected production or his net contribution to the national product.²⁰

This argument, however, has no general validity and is true only in a special case.

*In a special case where a woman could work only as a housekeeper, her earnings as a housekeeper will represent the low as well as the high value of her services.

**Waaler is an economist with Det Sentrale Tuberkuloseregister, Statens Skjerm-bildefotografering, Oslo, Norway.

It is true that any contribution to national product will give us a measure of the value of benefits of an activity or a program to society. But for that purpose Waaler's approach is not the one to be followed. When we compute the national product of an economy, we count an individual's gross income without making any deductions for his consumption. In fact, if we agree to Waaler's suggestion, we will treat members of society as pieces of physical capital and subtract their consumption from GNP to find out the net national product (NNP) of an economy as we deduct, according to present practices, depreciation or capital consumption allowance.

But this is not the way that we treat the members of our society. It is actually to satisfy their demands that an economy functions. It is basically unsatiability of their wants as consumers and their desire for ever-rising standards of living that prod economies towards higher and higher levels of development, and that save even the most affluent societies from "secular stagnation".

Waaler is, however, right if the question before us is: What the survivors, including his family and the rest of the members of society, will lose if a person dies? In our study, however, this is not the relevant question. Ours is an ex-post study and we are to estimate the life-time production of those whose lives have already been saved from falling prey to tuberculosis. These people (they are not identified individuals) live as members of society until they die from some other cause. And, therefore, their gross income, like that of every other member of society, is to be counted

as a part of national product and hence should be included in measuring the benefits of the TCP in Ontario. Moreover, even in the case of ex-ante studies it is gross rather than net output which should be used for calculating V_n . It is not just the survivors who make the investment -- through the government -- in programs like the TCP, but everyone including potential victims, so benefits to everyone (not just the survivors) should be counted. Accordingly, no deductions will be made for consumption.

(d) Full Employment of Resources

It is assumed that resources in the economy are fully employed. This assumption in fact has already been implicitly introduced, when we decided that earnings will represent a person's real contribution to society in any particular year. It is true that if there is unemployment in an economy, health programs may worsen the situation rather than help it. But then, as it has been pointed out, the blame should lie where it belongs (with unemployment) and not with health programs as such.²¹ Moreover in the post-World War II era most governments in advanced economies are committed to maintain full employment and they follow varied monetary and fiscal policies to achieve it. It can, therefore, be argued that even if there is no full employment at a certain time, government will be making consistent efforts to attain it and "cost-benefit techniques used to evaluate projects should not be adjusted when national employment falls short of the government target (full employment)."²² To sum

up, in order to properly evaluate the TCP on its own merits, we must assume that all workers earn income at their potential, full employment, rates.

Full employment, however, is not to be interpreted as 100 per cent utilization of labour resources. It is a target employment rate consistent with an acceptable rate of inflation and a balance in international payments. Then there is always frictional unemployment in every economy.

A 3% rate of unemployment is usually regarded as a satisfactory approximation of full employment. This is also the level of full employment assumed by the Economic Council of Canada. The labour force participation figures (P_n in formula 4.3) which are used in our calculations are therefore, multiplied by 0.97. Other researchers have worked with some different levels of unemployment as representing full employment of labour. For Weisbrod it is 5%; Rice and Cooper use a figure of 4%.²³

(e) Why Participation Rate?

The rationale for using P_n in (4.3) is that in order to get per capita average earnings, data on average earnings for every year have to be multiplied by the labour force participation rates for the respective years. This is necessitated by the nature of the data available to us. The data on average earnings in a particular year are given for only those males and females who had earnings during that year.²⁴ As we know a proportion of persons in any age group does not work and hence the necessity for adjustment in our data in order

to get average earnings per person.

D. Discount Rate -- i

A final, but important question remains. What rate of interest should be used for purposes of discounting? The objective of discounting is to express the value (in dollars) of some future economic action in terms of present (dollars). But why should we discount? This question has already been faced (see supra, p. 53). There is a long and continuing debate on the problem of what rate of discount to use. There are three schools of thought. One considers that the long-term rate of interest at which the government of the country is able to borrow is the appropriate rate of discount for public projects. Another favours the use of the social time preference (STP) rate and the third argues for the rate representing the social opportunity cost of capital (SOC). Their respective positions have been appraised in "Appendix A". It is suggested there that we will use three different rates of interest -- 4, 8, and 15 per cent -- to calculate Va_t and to measure the NPV (B-C) or B/C of the TCP in Ontario. It is assumed that 15% approximates the SOC and 4% the STP. Eight per cent is selected as an approximation for the mid-point rate between the two. It is also noted there that these rates are to be interpreted as real and not financial rates of interest. Moreover, they are to be taken as the rates unadjusted for any risks or uncertainties.

One thing which we want to emphasize here is that the choice of rate of discount is of vital importance. At

times the fate of a project may be decided simply by this choice alone. Some projects may become desirable at lower rates of interest while they would never pass muster at higher rates. For example, Fox and Herfindahl found that if the Corps of Engineers in analyzing prospective projects raised their interest (or discount) rate from 2.5, to 4, 6, or 8 per cent, then out of the initial set of projects which had $B/C > 1$ at 2.5%, respectively 9, 64, and 80 per cent of the projects would have had a benefit-cost ratio of less than unity.²⁵ To emphasize how sensitive the efficiency of a project is to the choice of rate of interest, we could not resist quoting one of Kenneth Boulding's verses:²⁶

Around the mysteries of finance
We must perform a ritual dance
Because the long-term interest rate
Determines any project's fate:
At two per cent the case is clear,
At three, some shaking doubts appear,
At four, it draws its final breath
While five per cent is certain death.

1.2 Benefits from Reduced Disability -- B_2

Benefits from reduced disability (B_2) will be calculated by using the following formula:

$$B_2 = \sum_{t=t_0}^T \left[\sum_{n=15}^{70+} (R_{n,m} \cdot Y_{n,m} \cdot H)_t + \sum_{n=15}^{70+} (R_{n,f} \cdot Y_{n,f} \cdot H)_t \right] \cdot \frac{1}{(1+i)^{t-t_0}} \quad (4.4)$$

where,

$R_{n,m}$ = Annual reduction in tuberculosis cases in males of age n years;

$Y_{n,m}$ = Average annual earnings of a male of age n years;

H = Average period of disability, in units of years;

$R_{n,f}$ = Annual reduction in tuberculosis cases in females of age n years;

$Y_{n,f}$ = Average annual earnings of a female of age n years;

t_0 = Base year as in (4.1)

T = Terminal year as in (4.1)

A. Reduction in the Number of Tuberculosis Cases -- R_n

In order to calculate $R_{n,m}$ and $R_{n,f}$ we need to know the age and sex-specific incidence of tuberculosis (new cases of TB in a year) as it has been from 1948 to 1966 and as it would have been had the TCP remained at the pre-1948 level. The difference between the two figures will give the required data. For the former we have the data on the actual annual incidence of tuberculosis by age and sex from 1948 to 1966. For the latter we have to make projections. For making these projections we use a method exactly similar to the one used for mortality projections (see supra, pp. 77-79). The only difference is that in formula (4.2), age-specific mortality rate (qM_x^1) is to be replaced by age-specific incidence or morbidity rate (qI_x^1). qI_x^1 is assumed to remain constant at the average level of such rates in 1945-1947. This assumption is made for a similar reason for which it was adopted for producing tuberculosis death projections.

There are other possible projection methods which could be used, but we have decided against using them. Below we explain briefly the reasons for our decision.

We decided against trend-fitting method for reasons

similar to those for which we did not use it for projecting deaths from tuberculosis (see supra, p. 79). The fluctuations in the age-specific incidence rates from year to year were sufficiently wide as to give no evidence of any clear trend.

A few more sophisticated methods have been suggested in the literature. One such method is given by Waaler, Geser and Andersen.* Their basic premise is that "the epidemiological factors, such as prevalence and incidence of infection and disease, are mutually dependent and between them determine the trend of tuberculosis. These factors are closely linked together in a set of relationships."²⁷ By postulating a set of equations and making simplifying assumptions they succeed in constructing a simple epidemetric model, reflecting the dynamics of tuberculosis. By utilizing difference equation methods they project the time trend of tuberculosis prevalence in three different situations: (1) when there are no controls. This they call the spontaneous time trend; (2) when under one imaginary control program two-thirds of the cases are detected and successfully treated; and (3) when there is a BCG** campaign which keeps 70% of all infected efficiently vaccinated in the area.

Their model can be used to project the time trend of morbidity or incidence of tuberculosis. But the data requirements for using their model are immense and cannot be

*Waaler was WHO senior statistician, Geser was WHO epidemiologist and Andersen was senior WHO officer, World Health Organization, National Tuberculosis Institute, Bangalore, India.

**Bacillus Calmette-Guerin. A vaccine used to vaccinate human beings against tuberculosis.

fulfilled, given the present state of data in Ontario. To use their model, we will require data on the following: prevalence of infection, prevalence of cases, annual incidence of infection, annual rate of healing and annual death rates in three subgroups of the population -- the noninfected, the infected non cases and the cases. These data will be required for at least one year in the period immediately preceding the TCP in Ontario. These statistics are not available even in aggregate not to speak of by age and sex.

The authors of the model themselves were faced with the scarcity-of-data problem. They were quick to realize that to satisfy the data needs, we may have to have "longitudinal surveys in large random samples of population groups."²⁸ To illustrate the potential uses of their model, however, they solve it by plugging in data derived mainly from Frimodt-Moller's* longitudinal survey in South India.²⁹ It is significant to note their comment on this data source. They state that "these data appear to be among the most complete which are available anywhere in the field of tuberculosis epidemiology. Even these data must, however, be taken with some reservations since inherent difficulties make certain estimates rather doubtful."³⁰

We thought of making a few very simplifying assumptions to reduce the data requirements to the minimum possible.

*Frimodt-Moller was chief, WHO Tuberculosis Research Office Madanapalle Field Research Station, Madanapalle, South India.

At a minimum we need tuberculosis infection rates* by age and sex for a year in the period immediately preceding 1948. Even this requirement could not be satisfied. We could not find any published statistics on it. We contacted Dr. Ashley of the Epidemiology Service, Ontario Department of Health. She was very helpful indeed. But she could find these data only for 1958-60. She sent them to us with a letter saying that "these are the latest and the only data which I could find for the province as a whole."³¹ (Italics mine). Obviously we could not use those figures for projecting tuberculosis morbidity in Ontario as it would have been in the absence of the extended TCP.

Another method has been presented by ReVelle, Lynn and Feldmann.** They describe their model in a system of nine differential equations--which state the dynamics of the disease in mathematical terms. The emphasis of their model, they state, is "on tuberculosis control in developing nations where high prevalences of active cases are observed, but the descriptive model may be applied for simple projection purposes to technologically advanced nations as well."³² But the data requirements in the case of this model too are at least as great, if not greater than, as in the case of the earlier one. This should be clear from the fact that most

*For definition of infection rates see supra, p. 80, n.

**They were respectively from the Centre for Environmental Quality Management, Cornell University College of Engineering and the Department of Public Health, Cornell University Medical College.

of the data, which they utilize to illustrate the uses of their model, are taken from the Waaler - Geser and Andersen model itself, i.e., the first model described above.

Our method, therefore, was the best which could be used. Methods, similar to ours, have been used to forecast the morbidity of some diseases. For example, Cutler and Haenszel* used the age-specific cancer incidence rates as observed in 10 urban areas of the States in 1947 to forecast the cancer incidence (new cases of cancer) in the U.S.A. for the years 1960 to 1975.³³ Weisbrod recently calculated the number of polio cases expected in the U.S.A. "for each year following 1957" in the event that there would have been no successful research-vaccination program. He used a method quite similar to ours.³⁴

B. Tuberculosis Incidence Rate

Our method makes use of the age-and-sex specific tuberculosis incidence rates to prepare projections of tuberculosis cases in the absence of the TCP. The important question to be considered is what represents the tuberculosis incidence? Is it the number of patients in the TB institutions or the notification of new TB cases or some other such index? The number of patients in TB institutions (sanatoria) cannot be a proper index for our purpose. It represents tuberculosis prevalence rather than incidence. That this is so becomes clear from the following definitions of the two

*Cutler was an analytical statistician in the Biometry Section in the National Cancer Institute, U.S.A. Haenszel was the head of that Section.

concepts:

1. The incidence is based on the number of new cases developing in a given year.
2. The prevalence is the total number of all types of living cases of tuberculosis, some of whom have been known for years.³⁵

Clearly, if we use the figures for patients in tuberculosis institutions to calculate B_2 , we will be double counting.

Dr. C.A. Wicks, superintendent of the Toronto Hospital for Tuberculosis, considered using "notifications of new cases of active tuberculosis plus the number of relapses each year by age and sex groups" as a reasonably good index of tuberculosis morbidity (incidence). But he justifiably rejected it on two grounds: (1) notification of new active tuberculosis cases is less than the actual number. He implies thereby that the reporting of tuberculosis, though required by law, is not perfect; (2) Figures regarding relapse of tuberculosis are not readily available. He concluded that under these circumstances one is "limited in a choice of presently available yardsticks of tuberculosis morbidity to 'tuberculosis first admissions to tuberculosis institutions'."³⁶

Other medical experts also agree with Wick's conclusion. For example, Brink, while investigating whether the incidence of TB in Ontario has gone down or not over a period of time, makes the following statement:

The number of cases entering sanatoria for the first time can be compared from year to year and is a fairly good index for measuring the incidence of the disease.³⁷

In the absence of any better indicator of tuberculosis incidence we will also use it (first admissions to tuberculosis institutions) for purposes of our calculations.

C. Other Data

The data on the other required variables, i.e. $Y_{n,m}$, $Y_{n,f}$ and H are available. For $Y_{n,m}$ and $Y_{n,f}$, the same data will be used as in (4.3) For H , we will use the data on mean hospital stay of tuberculosis patients in Ontario.

1.3 Benefits from Reduced Debility -- B_3

To estimate the benefits to society from reduced debility (i.e. B_3) is not possible. There may be some people who have tuberculosis but the disease in their case has not yet been detected. In all probability the productivity of these people will be adversely affected. The TCP in Ontario must have helped reduce the number of such cases. But we do not have any data on it. Moreover we do not know to what extent the undetected tuberculosis adversely affects a person's productivity. We are, therefore, not able to give any quantified results for B_3 .

It could be argued that ex-TB patients* may also suffer from reduced productivity on the job and this factor, if true, will effect our measure of the benefits of the

*An ex-TB patient is one who had tuberculosis in the past but since then has been cured of it.

TCP.* We do not have much evidence on how the productivity of ex-TB patients is affected. However, whatever evidence we have suggests strongly that tuberculosis, once cured, does not affect adversely a person's productivity on the job.

We know of only one report which studied the work performance records of ex-tuberculosis employees and compared them with those of unimpaired industrial employees. It concluded that "the ex-tuberculosis employees studied in this survey were 'normal workers who, properly placed, were able to compete successfully with unimpaired workers on the same jobs'."³⁸ The report studied the work performance of physically impaired workers in general. In one chapter the work performance of 513 ex-tuberculous workers was analysed as against that of a control group of 910 unimpaired workers.**

However, the impossibility of quantifying B_3 in the other possible cases (mentioned above) imparts a downward bias to the estimates of the benefits of the program as prepared in our study. This of course is in keeping with our basic approach to the benefit calculations in our research, i.e., to estimate benefits conservatively (cf., p. 75).

We can now sum up the marginal (incremental) benefits side of our analysis for the TCP in Ontario, to the

*There will be another category of such people whose disease has been detected but they have not yet been cured of it. These people will be in sanatoria and thus accounted for while calculating B_2 . To the extent that they are not in sanatoria but on the job working with reduced productivity our estimated benefits of the program will be downward biased.

**It could be argued that...(continued on the following page)

Continuation of footnote ** from page 100

...some of the old ex-patients who were cured mainly by surgery, in the immediate post-chemotherapy era, would have reduced productivity on the job. In the extreme cases they may never join the labour force again. The "Extended TCP" helped by "wonder drugs" must have reduced the number of such cases. However, the benefits of the program resulting from this phenomenon cannot be measured.

extent that we are able to estimate these in numerical form. They are simply $B = B_1 + B_2$. These benefits, as mentioned earlier, are deflated and expressed in constant 1949 dollars.

2. Costs of the Program

Costs of our project are defined as total inputs of goods and services (in dollar terms) which had to be incurred on the TCP in Ontario from 1948 to 1966. It may again be remembered that we are interested in measuring the marginal costs * (MC) of the TCP (see supra, pp. 9-10). These marginal costs for every year are measured as the difference between the actual total costs (TC) incurred every year from 1948 to 1966 and the projected total costs that would have been incurred in the absence of the TCP as started in 1948.

Actual total costs (TC) incurred every year from 1948 to 1966 will be calculated by summing the costs incurred by various sources and agencies who spend on the TCP in Ontario, or in other words TC for every year will be defined as:

$$TC = C_1 + C_2 + C_3 \quad (4.5)$$

where

C_1 = All costs incurred by the provincial government;

C_2 = All costs incurred by the federal government;

C_3 = Costs incurred by the voluntary associations like the Ontario Tuberculosis Association.

*The reader may be reminded that we have defined marginal costs as any finite incremental or decremental costs of the project (cf., p. 9).

We may note here that in calculating these costs (in Chapter V) full care is taken to avoid double counting. The steps taken for this purpose are outlined there. Research costs are not included because all the drugs used in the treatment of tuberculosis were discovered outside Canada.

To arrive at the projected total costs which would have occurred from 1948 to 1966 without an expanded TCP we use the projected per capita costs, $\frac{TC_p}{N^p} = tc_p$, multiplied by total population, N.

Then

$$MC_t = TC_t - TC_{p,t} \quad (4.6)$$

and C, component in NPV (B-C) or B/C is given by

$$C = \sum_{t=t_0}^T MC_t \cdot \frac{1}{(1+i)^{t-t_0}} \quad (4.7)$$

where

t_0 and T have the same meaning as in (4.1).

It is assumed that tc_p , to be consistent with our method used to produce tuberculosis mortality and morbidity projections, will remain constant at the average level of per capita costs that obtained in the period 1945 to 1947. The average of per capita costs in three years prior to 1948 rather than the per capita cost in 1947 alone is used to mitigate the effect of any extraordinarily large costs which might have occurred in 1947.*

It could be argued that tc_p in the period under

*This reason is similar to the one for which qI_x^1 and qM_x^1 were used for making tuberculosis mortality and morbidity projections (see supra, pp. 78 and 93).

study (1948 to 1966) would have declined in the absence of the extended tuberculosis control program. The argument could be made as follows. In this period population in Ontario increased at a very high rate, especially up to the late fifties: the period of the baby boom and high immigration. It is doubtful that in the absence of the expanded TCP, made possible by the federal health grants for tuberculosis control and aided by the discovery of antibiotics (which finally provided mankind with a highly effective cure for tuberculosis), the total expenditure on tuberculosis would have increased sufficiently to keep pace with the increase in population.*

To take account of this line of argument, we assume in an alternative set of calculations that the projected total costs of the program, not its per capita costs, remain constant at the average level of these costs in 1945 to 1947. In other words, we allow tc_p to fall. This assumption provides us with another set of the projected total costs and the corresponding set of the marginal costs of the program. The results corresponding to the two alternative assumptions are presented and analyzed in Chapter V (see infra, pp. 167-174).

3. Some Other Considerations

3.1 Environmental Factors and Tuberculosis

Before we close this chapter, a few other points of

*For a brief history of the discovery of "wonder drugs" and the role of the federal grants in the TCP in Ontario (see supra, pp. 17-19).

great importance and relevance to our study should be considered. It is pointed out that in addition to the discovery of "wonder drugs" and their availability to all patients, made possible by the extended TCP, the fight against tuberculosis has been greatly aided by environmental factors.* These environmental factors can often be represented by per capita real income largely because most of these factors (like nutrition, housing and education, etc.) tend to be highly correlated with real income. The favourable effects of increasing real income and hence that of rising standards of living on the levels of health in an economy are pretty much emphasized. Such favourable effects are said to be particularly significant in the case of tuberculosis.

We could partly attribute the decline of tuberculosis to environmental changes; but we tend to agree with Springett, the former president of the British Thoracic and Tuberculosis Association, that "the dramatic improvements in the tuberculosis situation are due largely to efficient chemotherapy..."³⁹

Fuchs has done a comprehensive study on the contribution of health services to the American economy.⁴⁰ In it he comments that during the last twenty-five years the single most important factor responsible for improvements in health levels probably has been improvements in (medical) technology.**

*Environmental factors are usually defined as factors like nutrition, housing, education, occupation, urbanization and recreation, etc.

**Improved technology in the medical field is defined as better drugs, better medical knowledge and better diagnostic techniques, etc.

He also adds that medical services have been demonstrably effective in controlling the infectious diseases and that though we can attribute the decline of tuberculosis in part to environmental changes, the principal cause for decline in the tuberculosis death rate remains the provision of improved medical services.

He compares the crude death rates for tuberculosis in five European countries in 1960 with the rates in the United States in 1960 and 1925. His figures are reproduced below:

TABLE 4.1
COMPARISON OF TUBERCULOSIS DEATH RATES
OF UNITED STATES IN 1925 AND 1960
WITH RATES IN EUROPEAN COUNTRIES IN 1960

Country	Crude Death Rates Per 100,000 Population Tuberculosis (all forms)
<u>1925</u>	
United States	84.8
<u>1960</u>	
United States	5.9
England & Wales	7.5
France	22.1
West Germany (excluding Berlin)	16.2
Netherlands	2.8
Belgium	17.1

Source: Victor R. Fuchs, "The Contribution of Health Services to the American Economy", Milbank Memorial Fund Quarterly, 44 (Number II, October, 1960), Table 2, p. 82.

Fuchs selects the 1925-data for the U.S.A. because the five European countries, studied by him, in 1960 had real per capita income at a level which was roughly comparable to that of the States in 1925. He points out that the death rates in general are higher for the European countries because of the fact that older people are in larger proportion there. In spite of this bias the tuberculosis mortality rates are much closer to the rates in the U.S.A. in 1960 rather than in 1925. From this he rightly concludes that, "one explanation worth investigating is that the European countries enjoy a medical technology that is similar to that of the United States in 1960, and that changes in medical technology have been the principal cause of the decrease in the United States death rate from 1925 to 1960."⁴¹

We think that a similar conclusion could be drawn for Ontario also and we may say that the extended TCP along with "wonder drugs" is the main cause of decline in tuberculosis in Ontario.

We have mentioned above that the environmental factors could also be given credit for bringing tuberculosis under control in Ontario. But just what proportion, howsoever small, of the benefits of the TCP should be attributed to rising standards of living and environmental factors is not clear. All environmental changes may not have a positive effect on tuberculosis control. For example, nutritious diet will increase a person's resistance against tuberculosis but his migration to over-crowded big industrial centres, a

common phenomenon in a modern industrial country like Canada, faced with housing congestion and air pollution will probably affect his health adversely and thus decrease his resistance to tuberculosis. What the net result will be is an important empirical question, though a very hard one to answer.

For all these reasons, we have decided not to make any adjustments in benefits or costs of the TCP for the environmental changes that have occurred over the period 1948-1966.

3.2 Technological Change and Benefits of the Tuberculosis Control Program

We have concluded that improvement in medical technology and the availability of this technology to the patients under the TCP have been the principal causes of decline in the tuberculosis problem in Ontario.

In 1948, the year when the "Expanded Tuberculosis Control Program" was started in Ontario, two developments took place simultaneously:

1. Quality of medical services available for treatment of TB improved. "Wonder drugs" were becoming available.
2. Increased amounts of public funds were being spent to take advantage of the new drugs and to extend the preventive measures.

We are, therefore, confronted with an important question: What proportion of the benefits of the TCP in Ontario should be attributed to development 1, i.e., the improved technology in the treatment of TB, and what proportion should be accredited to development 2?

This is a very intricate question. The two pheno-

mena are very much interrelated as far as their role in controlling tuberculosis is concerned. Tuberculosis could not have been controlled had either of them not occurred. Before the discovery of chemotherapy there was no really effective treatment available for this disease. In fact, bed rest and collapse therapy (largely artificial pneumothorax), represented the most accepted form of treatment. As mentioned earlier (see supra, p. 18) there are three major drugs which are used in the treatment of TB: Streptomycin, PAS and Isoniazid. The use of streptomycin for tuberculosis treatment was first reported in 1947-48 and that of PAS in 1949 and very soon the two were being used in combination. The third drug was first used in 1952.

But had the government not provided funds* for making these drugs available to all patients free of charge, their use would have progressed very slowly and the TB control in Ontario would not have been so successful (see supra, p. 19).

Under the circumstances how do we distribute the total benefits of the program between the two factors responsible for its success. Below we suggest a possible method. It may not be an ideal one but given the complicated nature of the problem and the data limitations, it seems to be the best.

The discovery and the use of chemotherapy affected

*Public funds were of course used for financing the other aspects, like case finding activities, of the TCP in Ontario. For a brief description of the TCP and its historical evolution, see Chapter I.

tuberculosis mortality and morbidity, the two components of total benefits of the TCP as measured in this study, by making it possible to cure it very effectively.

It is a well known fact that the chemotherapeutic treatment of tuberculosis has saved the lives of hundreds of thousands of tuberculosis patients throughout the world. The treatment has also reduced the morbidity of this most infectious disease. It is generally recognized that "in most countries sputum is the main source of tuberculous infection. If all patients could be treated and their sputum converted to negative, new infections would cease. For a time new cases would continue to arise from previous infections, but this source should gradually decrease."⁴² There is evidence to suggest that even advanced cases when treated with satisfactory chemotherapy almost immediately cease to be a source of infection.⁴³ The chemotherapeutic treatment thus reduces the pool of infection in the country and hence the morbidity of the disease. New people are not exposed to as many sources of infection as in the absence of effective treatment.

It is evident, therefore, that if we succeed in measuring the degree of influence of the "wonder drugs" on the efficacy of treatment of tuberculosis, we could use it to approximate the effect of these drugs on tuberculous mortality and morbidity and hence on the total benefits of the TCP. For example, if we find that the use of chemotherapy made the tuberculosis treatment $x\%$ more effective, we could argue that $x\%$ of the total benefits of the TCP should be attributed to the use of antimicrobial drugs.

Following Drolet and Lowell of the New York Tuberculosis and Health Association we measure the influence of these drugs on tuberculosis treatment by studying their effect on the case-fatality rate.⁴⁴ It is defined as the ratio of deaths to the new cases reported. Prior to the introduction of chemotherapeutic treatment "there was a relatively constant relationship between infection, development of disease and progression to death."⁴⁵ Consequently, the case-fatality rates had not shown any improvement for more than twenty years.⁴⁶ With the use of drug treatment they started falling.

To determine the effect of drugs on the case-fatality rates we should study such a sample of patients which is almost entirely treated by drug therapy. Not only the availability of drugs but also the extent of their use will influence these rates. But in the beginning when chemotherapy was introduced it did not entirely replace the traditional bed rest treatment. Drug treatment was not always started immediately after diagnosis.⁴⁷

Drolet and Lowell have access to the right kind of data.⁴⁸ They study the case fatality rates among tuberculous patients hospitalized by the U.S. Veterans Administration. The administration had launched a large-scale test of streptomycin in the latter part of 1946 on hundreds of patients in collaboration with the Army and the Navy. With streptomycin widely used by the administration in 1947-48, the case fatality rate, compared to the rate in 1946, dropped by one-

third in 1948. In 1949 PAS was used as a companion drug for streptomycin. The dual-drug therapy brought a further decline in the case fatality rate among tuberculous patients of the U.S. Veterans Administration. It was down by 50% compared to the rate in 1946. Moreover, it stabilized itself around the level obtained in 1949 (10 per cent) till the introduction of isoniazid, the third of the "wonder drugs". Its use in 1952 among the veterans hospitalized because of tuberculosis affected a further fall in the case fatality rate among them. In 1953 it was practically only one-third of the 1946 rate.

Drolet and Lowell's study of the case-fatality rate among the patients of the Sea View Hospital, one of the largest institutions for the treatment of tuberculosis in the world, led them to the conclusion that in 1953, when more than 90 per cent of the patients were receiving isoniazid therapy, it was practically one-third of the rate in 1947.⁴⁹

There is not much detailed information available to enable us to analyze the effect of chemotherapy on the morbidity rates. Whatever evidence is available, however, suggests that the effect of chemotherapy on tuberculosis incidence was similar to the one on mortality. Crofton points out that in Edinburgh (England) when good chemotherapy became available for all patients, new cases (as indicated by notifications) first fell by 47% and later by 68%.⁵⁰

In light of the above findings, we decided that improved medical technology resulting mainly from the discovery of antibiotics could be credited for one-third of the

total benefits of the TCP in 1948; one-half in 1949 to 1952 and two-thirds in 1953 and onwards. Accordingly, in order to measure the NPV(B-C), B/C or the rate of return on investment in the TCP after allowing for the beneficial effects of chemotherapy, the estimates of the annual benefits from the program are adjusted downwards each year by the above proportions. For example, the estimated benefits in 1948 are reduced by one-third, in 1949 by one-half and so on.

It should be noted here that this adjustment in the estimated benefits of the program is warranted only if each year the best available chemotherapy was used on a large scale. To the extent that this assumption did not hold in Ontario the benefits of the TCP will be underestimated. To repeat ourselves, this will be in accordance with the basic philosophy of our study (see supra, p. 75) and the true value of the NPV (B-C) or B/C of the program should lie above the figure resulting from our research.

The results of our research are reported in the next chapter. They are given for the TCP after allowing for the beneficial effects of chemotherapy and without accounting for these effects. In each case the results are presented for the three criteria of project selection discussed in Chapter III.

FOOTNOTES

¹This terminology has been borrowed from Selma J. Mushkin, "Health as an Investment", JPE, 70, Supplement (October, 1962), 138.

²Louis I. Dublin, "The Course of Tuberculosis Mortality and Morbidity in the United States", AJPH, 48 (November, 1958), pp. 1439-1448.

³These rates are reported in Province of Ontario, Sessional Papers, issued annually, Report Relating to the Registration of Births, Marriages and Deaths in the Province of Ontario (Toronto, Queen's Printer).

⁴Floyd M. Feldmann, "How Much Control of Tuberculosis: 1937-1957-1977?", AJPH, 47 (October, 1957), pp. 1235-1241.

⁵Ibid., p. 1240.

⁶Earl R. Rolph and George F. Break, Public Finance (New York: The Ronald Press Company, 1961), p. 197.

⁷For a detailed discussion on insurance as an index of the value of a human life to society see Burton A. Weisbrod, Economics of Public Health, (Philadelphia: University of Pennsylvania Press, 1961), pp. 36-38; Gary Fromm, comments on a paper by T.C. Schelling, "The Life You Save May be Your Own", in Problems in Public Expenditure Analysis, ed. by Samuel B. Chase, Jr. (Washington, D.C.: The Brookings Institution, 1968), pp. 168-169.

⁸This formula is basically the same as used by Weisbrod. See Economics of Public Health, p. 48. Another variant of essentially the same formula may be found in one of the U.S. Government studies: Dorothy P. Rice, Estimating the Cost of Illness (Washington, D.C.: U.S. Department of Health, Education and Welfare, 1966), pp. 88-91.

⁹For a brief history of earlier attempts in this field see Dorothy P. Rice and Barbara S. Cooper, "The Economic Value of Human Life", AJPH, 57 (November, 1967), 1954-1966.

¹⁰Schelling, "The Life You Save", pp. 127-162.

¹¹Samuel B. Chase, Jr., "Introduction and Summary", in Problems in Public Expenditure Analysis, p. 19; Gary Fromm comments on "The Life You Save", p. 167.

¹²T.M. Brown, Canadian Economic Growth, a study prepared for the Royal Commission on Health Services (Ottawa: Queen's Printer, 1965), p. 159.

¹³D.J. Reynolds, "The Cost of Road Accidents", Journal of Royal Statistical Society, 119 (1956), 393-408; National Planning Association, Good Health is Good Business: A Summary of a Technical Study (Washington, D.C.: National Planning Association, 1948).

¹⁴Rashi Fein, Economics of Mental Illness (New York: Basic Books Inc., 1958), p. 17.

¹⁵Mushkin, "Health as an Investment", p. 141.

¹⁶Fein, Economics of Mental Illness, p. 23.

¹⁷Blaugh makes this point, though in a different context, see Mark Blaug, "The Rate of Return on Investment in Education in Great Britain", The Manchester School, (Sept., 1965), p. 225.

¹⁸Fein, Economics of Mental Illness, pp. 18-19; Rice and Cooper, "The Economic Value", p. 1959.

¹⁹Reynolds, "The Cost of Road Accidents".

²⁰H. TH. Waaler, "Some Aspects of Cost of Tuberculosis" in XVIIIth International Tuberculosis Conference, Proceedings of the Conference (New York: Excerpta Medica Foundation, 1966), p. 137.

²¹Mushkin, "Health as an Investment", p. 138.

²²Nevins D. Baxter, E. Philip Harvey and R.G. Penner, "Unemployment and Cost-Benefit Analysis", Public Finance, 24, No. 1 (1969), 85.

²³Weisbrod, Economics of Public Health, pp. 36-38; Rice and Cooper, "The Economic Value".

²⁴DBS, Distribution of Non-Farm Incomes in Canada by Size, several issues (Ottawa: Dominion Bureau of Statistics).

²⁵Irving K. Fox and Orris C. Herfindahl, "Attainment of Efficiency in Satisfying Demands for Water Resources", AER (May, 1964), 202.

²⁶ Kenneth E. Boulding, "The Economist and the Engineer: Economic Dynamics of Water Resource Development", in Economics and Public Policy in Water Resource Development, edited by Stephen C. Smith and Emery N. Castle (Ames: Iowa, Iowa State University Press, 1966), p. 84.

²⁷ Hans Waaler, Anton Geser and Stig Andersen, "The Use of Mathematical Models in the Study of the Epidemiology of Tuberculosis", AJPH, 52 (June, 1962), p. 1002.

²⁸ Ibid., p. 1012.

²⁹ J. Frimodt-Moller, "A Community-Wide Tuberculosis Study in a South Indian Rural Population, 1950-1955", Bulletin of the World Health Organization, 22 (1960), 61-70.

³⁰ Waaler, Geser and Andersen, "The Use of Mathematical Models", p. 1009.

³¹ M.J. Ashley, Personal Correspondence.

³² Charles S. ReVelle, Walter R. Lynn and Floyd Feldmann, "Mathematical Models for the Economic Allocation of Tuberculosis Control Activities in Developing Nations", American Review of Respiratory Disease, 96 (November, 1967), 893.

³³ Sidney J. Cutler and William M. Haenszel, "The Magnitude of the Cancer Problem", Public Health Reports, 69 (April, 1954), pp. 333-339.

³⁴ Burton A. Weisbrod, "Costs and Benefits of Medical Research: A Case Study of Poliomyelitis", JPE, 79 (May/June, 1971), 532.

³⁵ G.C. Brink, Tuberculosis in Ontario (Toronto: Ontario Department of Health, 1952), p. 3.

³⁶ C.A. Wicks, "Tuberculosis Mortality and Morbidity: Age and Sex Trends", CJPH, 48 (April, 1957), 146.

³⁷ Brink, Tuberculosis in Ontario, p. 4

³⁸ U.S. Department of Labor, Bureau of Labor Statistics, The Performance of Physically Impaired Workers in Manufacturing Industries, Bulletin No. 923 (Washington D.C.: U.S. Government Printing Office, 1948), pp. 97-103, quoted in "Ex-Tuberculosis Patients Show Good Work Records", PHR, 65 (February, 1950), 145.

³⁹V.H. Springett, "Tuberculosis Control in Britain: 1945-1970-1995", Tubercle, 52 (June, 1971), 145.

⁴⁰Victor R. Fuchs, "The Contribution of Health Services to the American Economy", Milbank Memorial Fund Quarterly, 44 (Number II: October, 1966), 82.

⁴¹Ibid., p. 83.

⁴²J. Crofton, "The Contribution of Treatment to the Prevention of Tuberculosis" in XVith International Tuberculosis Conference, Proceedings of the Conference (2 vols.: New York: Excerpta Medica Foundation, 1966), II, 643.

⁴³R.H. Andrews et al. "Prevalence of Tuberculosis Among Close Family Contacts of Tuberculosis Patients in South India and Influence of Segregation of the Patient on the Early Attack Rate", Bulletin of the World Health Organization, 23 (1960).

⁴⁴Godias J. Drolet and Anthony M. Lowell, "Where to Tuberculosis?", American Review of Tuberculosis and Pulmonary Diseases, 72 (October, 1955), 442-443.

⁴⁵Springett, "Tuberculosis Control in Britain", p. 420.

⁴⁶Drolet and Lowell, "Where to Tuberculosis?" p. 420.

⁴⁷V.H. Springett, "Ten-Year Results During the Introduction of Chemotherapy for Tuberculosis", Tubercle, 52 (June, 1971).

⁴⁸Drolet and Lowell, "Where to Tuberculosis?", p. 442.

⁴⁹Ibid., p. 443.

⁵⁰Crofton, "The Contribution of Treatment", p. 645.

CHAPTER V

BENEFIT-COST ANALYSIS OF TUBERCULOSIS CONTROL PROGRAM: RESULTS

We have already explained the methodology of measuring the marginal benefits and the marginal costs of the Tuberculosis Control Program (TCP) in Ontario. In this chapter we present the results obtained by using that methodology and some of the data needed for the purpose.

1. Benefits of the Program

The measured benefits of the program, as explained earlier, are equal to $B_1 + B_2$ (see supra, p. 101).

1.1 Benefits from Reduced Deaths -- B_1

To calculate B_1 , we use formula (4.1). It is clear from that formula that we have to have data on V_n (the present value of life-time earnings of a person of age n years) and D_n (reduction in the number of tuberculosis deaths of people of age n years) for 1948-1966 inclusive.

A. Present Value of Life-time Earnings -- V_n

To estimate V_n , we use formula (4.3). Before we present the results of these calculations, we would like to give some of the data used, explain the adjustments carried out on them and describe the assumptions made for these adjustments.

(a) Data on Earnings -- Y_n

The basic data on Y_n are presented in Table 5.1. These are the average (mean) income statistics for those people whose major source of income was wages and salaries and thus they represent earnings as distinguished from income. The latter includes returns on investment and property also. It is the earnings, as stated earlier (see supra, pp. 83-85) that measure a person's marginal productivity and hence the contribution of his labour services to gross national product. The survey reports from which the earnings statistics are taken cover only the non-farm incomes. We assume that these income statistics represent closely enough, for our purposes, the income of farmers and self-employed.

In some studies median instead of the mean earnings have been used, largely because the data on the latter have not been available.¹ It is generally recognized in the literature that for purposes like ours we should preferably use the mean rather than median earnings.²

The data given in Table 5.1 are for Canada. In Ontario the earnings on average are higher than the corresponding national figures. To take cognizance of this fact we adjusted the data. The factor of adjustment used is the ratio between the average earnings for all ages in Ontario for a particular year and its counterpart for Canada for that year. It is, therefore, invariant for each sex and age group. The adjusted data are presented in Table 5.2.

It may be noted that in Table 5.1, the age-groups

TABLE 5.1

AVERAGE EARNINGS BY AGE AND SEX, CANADA

		Average Earnings by Age (Dollars)										
		Males						Females				
Year/Age	19 and under	20-29	30-39	40-49	50-64	65+	19 and under	20-29	30-39	40-49	50-64	65+
1951	903	2,148	3,025	3,119	2,873	2,179	745	1,279	1,341	1,364	1,289	870
1954	954	2,568	3,488	3,617	3,517	2,836	791	1,560	1,560	1,566	1,579	1,492
1957	1,161	3,026	3,937	4,244	3,850	3,112	980	1,727	1,928	1,828	1,885	1,716
1959	1,067	3,124	4,216	4,398	4,145	3,664	1,005	1,897	1,996	2,012	2,055	1,397
Year/Age	24 and under	25-34	35-44	45-54	55-64	65+	24 and under	25-34	35-44	45-54	55-64	65+
1961	1,992	4,246	4,985	4,702	4,327	3,759	1,516	2,124	2,028	2,272	2,317	2,098
1965	2,208	5,254	6,458	6,003	5,045	3,728	1,644	2,339	2,382	2,562	2,620	2,262*

*Calculated by assuming that average earnings for this age-group increased between 1961 and 1965 in the same proportion in which the average earnings for all working females increased during this period. This was necessitated because the survey report from which all other data have been taken did not provide statistics for this age-group.

Sources: (1) D.B.S., Distribution of Non-farm Incomes in Canada by Size: 1951, 1954, 1957 and 1961. (Ottawa: Dominion Bureau of Statistics), tables 19, 22, 24, and 26 respectively.

(2) D.B.S., Income Distribution by Size in Canada: 1965 (Ottawa: Dominion Bureau of Statistics), table 27.

TABLE 5.2
AVERAGE EARNINGS BY AGE AND SEX, ONTARIO

Year/Age	Factor of Adjustment	Average Earnings by Age (Dollars)					
		19 and under	20-29	30-39	40-49	50-64	65+
		Males					
'1951	1.083	978	2,326	3,276	3,378	3,112	2,360
1954	1.049	1,001	2,694	3,659	3,794	3,689	2,975
1957	1.078	1,252	3,262	4,244	4,575	4,150	3,355
1959	1.058	1,129	3,305	4,461	4,653	4,385	3,877
1961	1.070	1,500	3,700	5,062	5,275	4,775	4,022
1965	1.069	1,725	4,375	6,350	6,737	5,687	3,988
		Females					
1951	1.083	807	1,385	1,452	1,477	1,396	942
1954	1.049	830	1,636	1,638	1,643	1,656	1,565
1957	1.078	1,056	1,862	2,078	1,971	2,032	1,850
1959	1.058	1,063	2,007	2,112	2,129	2,174	1,478
1961	1.070	1,175	1,950	2,220	2,300	2,460	2,245
1965	1.069	1,250	2,155	2,520	2,640	2,775	2,420

Source: Calculated from Table 5.1.

for which the data have been reported for 1961 and 1965 are different from the groups used for other years. But in Table 5.2, uniform age-groups for all years have been used.

To bring the 1961 and 1965 earnings into the same age groupings as for the earlier years, the data for these years (as given in Table 5.1) were graphed and the desired results were interpolated. In this process the average earnings in each age-class were imputed to its mid-point. The resulting statistics were then adjusted to account for the fact that average earnings in Ontario are higher than the earnings in Canada as a whole. This adjustment was carried out in the same way as for other years. The adjusted data appear in Table 5.2.

To develop the required time series of statistics on earnings by single year of age for each sex, the following procedures were adopted. The available data (Table 5.2) are for 1951, '54, '57, '59, '61 and '65 only. To complete the time series for the years 1948 to 1966, we must estimate the earnings statistics for the missing years. This was done by fitting the following linear regression for each sex and age-group.

$$Y = A + Bt \quad (5.1)$$

where

Y = Earnings for a particular sex and age-group

$t = T - t_0$; $T = 1951, 1954, 1957, 1959, 1961$ and 1965 .

$t_0 = 1950$

The regression gave a very good fit in all cases with high R^2 s and high t values for the co-efficients.

From these sex-specific data by age-groupings for each year from 1948 to 1966, we must estimate the annual earnings for each sex by single year of age. This was done by fitting the following equation to the mid-points of each age-grouping (16.5, 24.5, 34.5, 44.5, 57 and 70) for each sex and year separately.

$$Y = A + Bx + Cx^2 \quad (5.2)$$

where

Y = Income by age and sex

X = Age of a person in years

The regression gave a very good fit to the yearly data for each sex.* The fitted equation for each year and sex was then used to interpolate earnings by sex and single year of age: 14, 15, 16, 17, -----, 75 years. These estimated cross-sectional data on earnings by age and sex are used in our calculations. It has been mentioned that in estimating V_n values by age and sex for each year from 1948 to 1966, these cross-sectional data should be adjusted for the real growth in labour productivity and hence in earnings (see supra, pp. 84-85). This is indeed done in our V_n calculations. The method is explained below.

*In fact we had decided to fit this quadratic function to the annual data because the graph drawn from the data showed very clearly that earnings increase with age; reach a maximum; remain constant for some time; and then start falling.

(b) Rate of Growth in Earnings

It was estimated that over a period of 35 years (1926 to 1961) the real rate of growth in average annual earnings was 1.5 per cent. During this period, average productivity of labour or the real output per man-hour increased by an annual rate of 2.75 per cent.³ We would, therefore, expect that the real wage rate must have increased approximately at this rate. But the growth in real earnings per worker per year was smaller than the expected rate of increase in real wages because during this period there was a "pronounced growth in leisure" and the average annual hours of work per worker declined by 0.80 per cent per year.⁴ The method of arriving at our estimate of growth rate in average annual real earnings is outlined below and the data used for this purpose are presented in Table 5.3.

From those data, the ratio between the annual real earnings of a worker in 1961 and 1926 turns out to be 1.6825. From the compound interest rate tables it was calculated that one dollar will grow to \$1.6825 in 35 years (the period of growth under consideration) if it is allowed to grow at a yearly rate of 1.498 per cent or roughly at a rate of 1.5 per cent.

While calculating V_n values in a particular year we superimposed this rate of growth on an individual's income given by the cross-sectional pattern of earnings for that year. However, this was done indirectly by adjusting the rate of discount used for our calculations. When, for example,

TABLE 5.3

HOURLY EARNINGS AND HOURS OF WORK, CANADA
1926 and 1961

Year (1)	Average hourly earnings* (W_{hr}) (2)	Average hours of work per year per worker (h) (3)	$W_{hr} \cdot h$ (4) = (2) \cdot (3)
1926	0.7478	2,867	2143.9426
1961	1.6670	2,164	3607.3880

*Earnings are in 1957 dollars.

Source: T.M. Brown, Canadian Economic Growth, a study prepared for the Royal Commission on Health Services (Ottawa: Queen's Printer, 1965), pp. 194 and 216.

the rate of discount used was 4 per cent, we effectively used a discount rate of 2.463 per cent. The logic behind this procedure can be easily explained with the help of an example.

Suppose a person earns \$X per year at the present level of wages, prices and productivity. A year later his earnings at present prices will be = \$X·1.015 per year. Discounted at 4 per cent their present value will be = $\frac{\$X \cdot 1.015}{1.040}$ or = $\$X \div \frac{1.040}{1.015}$. So the effective rate of discount is given by $\frac{1.040}{1.015} = 1.02463$ or 2.463 per cent per year. The other discount rates used in V_n calculations are 8 per cent and 15 per cent. They were also adjusted for the growth rate of 1.5 per cent and hence the effective rates used were 6.403 per cent and 13.300 per cent.

(c) Value of Household Services

Another adjustment made in the income data was in the case of earnings of women. We have argued strongly that to a woman's average earnings we must add an imputed value for her work as a housewife (see supra, pp. 85-87). Following a suggestion given by Kuznets, we considered using the wages paid to domestic servants for this purpose.⁵ Unfortunately we could not get any data for the earnings of domestic servants in Ontario or in Canada. After a thorough search for the data, we decided to use the income statistics for a class of workers categorized in the 1961 Census as "Housekeepers (except private households), matrons and stewards". This measure may actually give a better estimate of the monetary

value of a housewife's work than the earnings of a domestic worker. She not only does the housekeeping work but at times performs the functions of matrons and stewards also for her family. The average earnings of a female worker in this group in Ontario were \$1910 per year in 1961. But we need a time series of data on this. To generate these data, we made the reasonable assumption that her yearly earnings experienced the same percentage change as was observed in the average (annual) weekly wages and salaries in the service industry in Ontario. We, however, hasten to add, lest the assumption should appear entirely unwarranted, that the service industry as defined here does not include government, community and health services.* The results obtained after applying this assumption to the 1961 data are put in Table 5.4. The imputed value for household work for a particular year is added to that year's age-specific average earnings figure for females. The average total earnings thus obtained are used in calculating the life-time earnings of females in that year. The data on the average weekly wages and salaries in the service industry are taken from Statistics Canada publications.⁶

We have added the imputed value of household work to every woman's average earnings. It could be argued that the value of household services should be taken into account only in the case of such women as do not work. If a woman works, her husband in all probability helps her in keeping the household. As we do not put any value on his household

*It includes hotels, restaurants, laundries and dry cleaning plants, etc.

TABLE 5.4

AVERAGE EARNINGS OF HOUSEKEEPERS (EXCEPT PRIVATE
HOUSEHOLDS), MATRONS AND STEWARDS, ONTARIO

Year	Earnings (Dollars)
1948	892
1949	950
1950	1,021
1951	1,105
1952	1,195
1953	1,296
1954	1,369
1955	1,432
1956	1,502
1957	1,609
1958	1,661
1959	1,727
1960	1,821
1961	1,910
1962	1,966
1963	2,016
1964	2,093
1965	2,195
1966	2,316

Source: See text.

services, so we should not put value on her services.

We, however, have not followed this approach. Even if a working woman's husband helps in household work, it is usually she who has to do the larger part of the household chores.

Moreover, the difference between our calculated V_n values for women and those that we will get by following the above alternative will be almost negligible. Therefore, no alternative measure of V_n values for women are produced.

The average earnings of a woman, if we follow the above suggestion, will be given by the following equation:

$$Y = (I \cdot N_w + H \cdot N_{nw}) \frac{1}{N} \quad (5.3)$$

where

Y = Average earnings per woman;

I = Income (wages) per working woman;

N_w = Number of working women;

N_{nw} = Number of non-working women;

$N = N_w + N_{nw}$;

H = Value of household services.

(5.3) can be written as

$$Y = (I \cdot N \cdot P + H \cdot N(1-P)) \frac{1}{N} \quad (5.4)$$

where

P = Labour force participation rate for women.

(5.4) can be simplified to

$$Y = I \cdot P + H(1-P) \quad (5.5)$$

As against (5.5), the average income of a woman

as used in our calculations, is given by*

$$Y = IP + H \quad (5.6)$$

Obviously the difference between (5.5) and (5.6) is very small, rather negligible, keeping in view that the values for both P and H are not very high.

(d) Data on Labour Force Participation Rates -- P_n

The basic data on labour force participation rates for both sexes are presented in Tables 5.5 and 5.6. The reader will note that these data are for Canada. No time-series data for 1948-1966 were available for Ontario. Only for the Census years, i.e., 1951 and 1961 could we find the data for the latter. A comparison of the regional (in our case Ontario) and national participation rates by age and sex in these years revealed that the national rates could be used as a very good proxy for the Ontario rates. To do this comparison we drew free-hand curves for the Canadian rates by age-groupings for each sex separately for 1951 and 1961. In each case it was found that the points indicating the Ontario

*Our formula can be deduced as follows. All the variables used in it have the same meaning as in equation (5.3) above.

$$Y = \left[(I+H) N_w + H \cdot N_{nw} \right] \cdot \frac{1}{N} \quad (5.7)$$

$$= \left[(I+H) P \cdot N + H(1-P)N \right] \frac{1}{N} \quad (5.8)$$

$$= (I+H)P + H(1-P) \quad (5.9)$$

$$= I \cdot P + H \quad (5.10)$$

TABLE 5.5

PARTICIPATION RATES FOR WOMEN BY AGE,
CANADA: 1948 - 1966

Year	14-19 %	20-24 %	25-34 %	35-44 %	45-54 %	55-64 %	65+ %
1948	33.4	45.5		22.8		16.2	5.0
1949	35.1	46.0		22.9		15.4	4.7
1950	33.0	46.4	24.0	20.5	18.9	13.2	4.2
1951	34.2	46.9	24.0	21.3	20.3	12.7	4.1
1952	33.1	47.1	24.1	22.5	20.6	13.4	3.9
1953	33.1	47.1		23.1		17.3	3.7
1954	33.7	46.7		23.3		18.1	3.8
1955	32.9	46.3		23.8		19.0	4.0
1956	33.9	47.1		24.5		20.8	4.5
1957	33.0	46.5		25.7		22.8	5.1
1958	32.0	47.4		26.2		24.0	5.3
1959	32.1	46.5		27.0		25.1	5.2
1960	32.6	48.0		28.4		26.6	5.6
1961	32.3	48.7		29.1		28.5	5.8
1962	30.9	49.7		29.7		29.4	5.6
1963	29.9	50.2		30.5		30.5	5.9
1964	29.9	51.1		31.7		31.6	6.3
1965	30.2	52.6		32.6		32.9	6.0
1966	31.3	55.7		34.2		33.9	5.9

Sources: (1) For 1953 to 1966 - D.B.S., Seasonally Adjusted Labour Force Statistics (Jan. 1953-Dec. 1968) - Catalogue #71-201, pp. 83-87.

(2) For 1948 to 1952 - T.M. Brown, Canadian Economic Growth, A Study Prepared for the Royal Commission on Health Services (Ottawa: Queen's Printer, 1965), p. 197.

TABLE 5.6

PARTICIPATION RATES FOR MEN BY AGE,
CANADA: 1948 - 1966

Year	14-19 %	20-24 %	25-34 %	35-44 %	45-54 %	55-64 %	65+ %	
1948	57.9	92.1		97.9		93.1	44.0	
1949	58.1	93.5		97.9		93.0	42.9	
1950	55.9	93.0	96.9		98.1	96.0	86.8	40.4
1951	55.3	93.4	97.7		98.2	96.2	86.4	37.9
1952	52.8	92.9	98.8		97.9	95.9	86.5	36.7
1953	51.7	92.9		97.6		91.9	34.7	
1954	50.2	92.1		97.3		91.3	33.2	
1955	48.6	92.3		97.5		91.7	32.3	
1956	48.1	91.7		97.6		92.0	34.0	
1957	47.8	91.5		97.7		92.6	34.0	
1958	45.5	91.7		97.8		92.4	32.1	
1959	43.6	90.0		97.8		92.3	31.0	
1960	42.9	91.1		97.8		92.6	30.3	
1961	40.2	90.6		97.7		92.1	29.4	
1962	39.6	88.7		97.7		91.8	28.5	
1963	39.2	88.7		97.7		91.8	26.4	
1964	38.4	88.2		97.7		91.8	26.8	
1965	38.7	87.6		97.6		91.8	26.3	
1966	38.5	87.4		97.6		91.8	26.3	

Sources: (1) For 1953 to 1966 - D.B.S., Seasonally Adjusted Labour Force Statistics (Jan. 1953-Dec. 1968) - Catalogue #71-201, pp. 77-81.

(2) For 1948 to 1952 - T.M. Brown, Canadian Economic Growth, A Study Prepared for the Royal Commission on Health Services (Ottawa: Queen's Printers, 1965), p. 196.

rates by age were located very near to the curve for Canada. Hence the national labour force participation rates by age and sex are used in our calculations. The rates given in Tables 5.5 and 5.6 are annual averages.

For estimating the labour force participation rates by single year of age, we drew the free-hand curves for each year and each sex by imputing the participation rate for each age-bracket to its mid-point. From these curves then we read the required estimates.

A curve for any particular year would suggest that a functional relation existed between the labour force participation rate and age and that a quadratic function should give a good fit. We, therefore, tried to use the regression technique to estimate the participation rates by single year of age. The results were not satisfactory. Probably by fitting polynomials of degrees higher than two, we might have got better results. We did not have, however, a sufficient number of observations, and hence sufficient degrees of freedom, to try these. Hence we decided in favour of the above graphical method, though it is much more laborious and time-consuming.

(e) Data on Survival Rates -- $S_{a,n}$

Survival rates or probabilities are calculated by using the standard life-table techniques. Probability of a person of age 'a' years to survive to age n years is defined in the following way:

$$S_{a,n} = \frac{L_n}{L_a} \quad (5.11)$$

where

$S_{a,n}$ = Probability of an individual of a years of age surviving to age n years

L_n = Average number of persons living between age n and ' $n + 1$ ' years, from an original cohort of 100,000

and

L_a = is defined similarly to L_n

The L_n statistics for each sex are taken from the life-tables for Ontario. These tables trace the mortality and hence the survival experience of a cohort. A cohort is defined as a group of people to whom some event, in our case the birth and hence the start of life, happens in the same year. In a life-table it always starts with an initial hypothetical population of 100,000. A life-table is always based upon the conditions of mortality prevailing in a given year or a given period of time and hence any particular life-table does not remain relevant for a long period of time. For the period covered by our study: 1948-1966, three life-tables are available for Ontario. They are constructed on the basis of the mortality conditions prevalent in 1950-52, 1955-57 and 1960-62.⁷ For each year, therefore, the data on L_n are taken from the life-table of such a period as was nearer to that year and thus was apt to describe the mortality conditions of that year more accurately than any of the other available tables. On this basis, we decided to use the 1950-52 life-table figures in our calculations of V_n for the years 1948-1953 inclusive. For 1954 to 1958 inclusive, the

life-table data on L_n were taken from 1955-57 tables and the 1960-62 table statistics were used for the rest of the period covered by our study.

(f) Discounted Life-Time Earnings by Age and Sex

We can now report the estimated values of V_n calculated according to formula (4.3) on page 81. But to do so for all years, ages and by each sex will require a lot of space. In Table 5.7, we are, therefore, presenting the V_n values for 1948, 1957 and 1966 by each sex and by some selected ages. These years are chosen for the sole reason of their being the first, middle and last year of the period of our study. These V_n values, as is clear from the table, are in current dollar terms. Table 5.8 reproduces them in constant 1949-dollars, i.e., in real terms. The deflator used for this purpose is the consumer price index.* The time series data on this index are taken from Statistics Canada publications,⁸

B. Reduction in the Number of Tuberculous Deaths -- D_n

After computing V_n for each sex, the only other data that we need, before we can calculate B_1 , are the reductions in the number of tuberculous deaths by age and sex for each year from 1948 to 1966.

*It measures "the percentage change through time in the cost of purchasing a constant 'basket' of goods and services representing the consumption of a particular population group during a given period of time." DBS, The Consumer Price Index: January 1949-August 1952 (Ottawa: Dominion Bureau of Statistics), p. 10.

TABLE 5.7
DISCOUNTED LIFETIME MONETARY EARNINGS BY SEX AND
SELECTED YEARS OF AGE, ONTARIO, 1948, 1957 AND 1966
(Current Dollars)

Age	1948			1957			1966		
	Interest Rates Used for Discounting								
	4%	8%	15%	4%	8%	15%	4%	8%	15%
	Males								
1	35,239	9,424	1,584	61,311	16,427	2,710	85,517	22,772	3,654
10	44,274	16,627	4,920	76,888	28,931	8,400	107,088	40,048	11,309
20	54,068	27,933	13,364	94,519	49,384	23,718	132,571	69,444	33,104
30	53,357	32,375	18,090	92,887	57,190	32,313	130,754	81,361	46,299
40	44,665	30,722	19,283	76,269	53,268	33,920	105,849	74,831	48,165
50	30,796	23,729	16,761	50,313	39,353	28,276	67,671	53,673	39,142
60	15,177	12,970	10,356	22,329	19,321	15,701	27,186	23,908	19,857
70	3,003	2,832	2,586	3,570	3,368	3,076	3,105	2,945	2,714
75	220	220	220	230	230	230	170	170	170
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Females								
1	10,830	3,898	930	20,388	6,954	1,610	36,038	11,697	2,548
10	13,573	6,861	2,881	25,516	12,222	4,980	45,059	20,540	7,873
20	14,307	9,398	5,992	27,308	16,831	10,175	50,073	29,918	17,475
30	9,173	6,060	3,805	19,950	12,561	7,410	38,766	24,104	13,875
40	6,324	4,421	2,834	15,363	10,630	6,703	30,904	21,512	13,568
50	4,110	3,194	2,273	10,260	7,972	5,666	20,586	16,254	11,743
60	1,807	1,566	1,273	4,506	3,918	3,202	7,764	6,883	5,819
70	228	216	199	514	485	444	1,038	968	870
75	14	14	14	35	35	35	111	111	111
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: See Text.

TABLE 5.8
DISCOUNTED LIFETIME REAL EARNINGS BY SEX AND
SELECTED YEARS OF AGE, ONTARIO, 1948, 1957 AND 1966
(1949 Dollars)

Age	1948			1957			1966		
	Interest Rates Used for Discounting								
	4%	8%	15%	4%	8%	15%	4%	8%	15%
	Males								
1	36,328	9,715	1,633	50,293	13,475	2,223	59,426	15,824	2,539
10	45,642	17,141	5,072	63,071	23,732	6,891	74,415	27,829	7,859
20	55,739	28,796	13,777	77,534	40,510	19,456	92,124	48,257	23,004
30	55,006	33,375	18,649	76,195	46,913	26,506	90,861	56,538	32,173
40	46,045	31,671	19,879	62,563	43,696	27,825	73,554	52,000	33,470
50	31,746	24,462	17,279	41,272	32,281	23,195	47,025	37,297	27,200
60	15,646	13,371	10,676	18,316	15,849	12,880	18,892	16,614	13,799
70	3,096	2,920	2,666	2,928	2,763	2,523	2,158	2,046	1,886
75	227	227	227	189	189	189	118	118	118
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Females								
1	11,165	4,018	959	16,724	5,704	1,321	25,043	8,128	1,771
10	13,992	7,073	2,970	20,931	10,026	4,085	31,311	14,273	5,471
20	14,749	9,688	6,177	22,401	13,806	8,347	34,796	20,790	12,143
30	9,456	6,247	3,923	16,365	10,304	6,078	26,938	16,750	9,642
40	6,519	4,558	2,922	12,602	8,720	5,498	21,475	14,949	9,428
50	4,237	3,293	2,343	8,416	6,539	4,648	14,305	11,295	8,160
60	1,863	1,614	1,312	696	3,214	2,627	5,395	4,783	4,044
70	235	223	205	422	398	364	721	673	605
75	14	14	14	29	29	29	77	77	77
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: See Text.

These data were estimated by using the method already explained (see supra, pp. 77-80). For each sex the average tuberculous death rate by age (q^M_x) referred to there is the weighted average of age-specific death rates in 1945-1947. In each case the weights used are the age specific population of Ontario in each of these three years.

The statistics on actual number of deaths by all forms of tuberculosis by age and sex were taken from the various issues of the annual Report Relating to the Registration of Births, Marriages and Deaths in the Province of Ontario.⁹ The data on population by age and sex were also extracted from these reports for 1945 to 1951. For 1952 to 1966, the population figures were taken from the several annual issues of Statistics Canada publication: Vital Statistics.

C. Estimated Values of Benefits from Reduced Deaths -- B_1

We can now use formula (4.1) to calculate B_1 . We did, however, make one very minor modification in it. The data used for each sex were for given age-groups rather than for age by single year. The age-groups used were such as corresponded with those groups for which data on actual tuberculous deaths were available and hence for which D_n values were estimated. V_n values for the corresponding age-groups were found by attributing to each age-class a value equal to an average of V_n values for all such ages (by single year of age) as were covered by that class interval. It may be worth mentioning here that the number and interval of age-groups for each sex, for which data on actual tuberculous deaths

are available (and hence for which D_n values are estimated), change over time. This was one of the reasons that we had decided to calculate V_n values by single year of age. This provided us with the flexibility of computing them for any necessary age-groups. Alternatively, we could have estimated D_n figures by single year of age through interpolation by drawing free-hand curves. But this would have involved unnecessary calculations on a large scale. Moreover it would have introduced considerable error in the estimates as the figures for some class intervals were quite small. We could not use the regression technique for this purpose because of the marked angularities in the curves.

The representative results of our calculations are presented in Table 5.9 for three years: 1948, 1957, and 1966. For each year the value of benefits from the reduced number of tuberculous deaths (B_1) has been discounted to 1948: the base year for our project.

1.2 Benefits from Reduced Disability -- B_2

We now turn our attention to measuring benefits from reduced morbidity. In this field we have to face some data problems. The record, at times, is sketchy. But, we think, we have succeeded (and this will become evident to the reader as he proceeds) in developing good data and thus in obtaining quite reliable estimates of B_2 .

To measure B_2 , it has already been explained, we will use formula (4.4) as given on page 92. We first describe the availability and development of data on the various

TABLE 5.9

BENEFITS FROM REDUCED TUBERCULOUS DEATHS DISCOUNTED TO 1948
 ONTARIO, 1948, 1957, and 1966.

(Current Dollars)

Year	Rates of Discount Used		
	4%	8%	15%
MALES			
1948	5,707,565	3,358,644	1,898,191
1957	26,182,624	11,547,729	3,912,637
1966	32,942,480	10,420,429	2,022,676
FEMALES			
1948	1,304,202	796,972	469,912
1957	5,722,917	2,428,451	792,172
1966	9,715,926	2,903,076	531,138

Source: See Text.

variables given in that formula, and then present the results of our calculations.

A. Data on Reduction in Tuberculous Cases -- R_n

The main data requirement for measuring B_2 is the estimates of annual reduction in tuberculous cases (patients) by age and sex for 1948-1966. These estimates were produced by the method already explained (see supra, pp. 93-97).

(a) Data on Tuberculosis Morbidity

To estimate R_n by age and sex by our method, we need data on tuberculous morbidity or incidence by age and sex for the years 1945 to 1966: for 1945 to 1947 to project the tuberculous cases and for the rest of the period to compute R_n . We mentioned in Chapter IV (p. 99) that we would adopt the conventional measure of morbidity and estimate it by annual first admissions to tuberculosis institutions. Unfortunately, such data were not available by age and sex. We, therefore, modified the morbidity measure in a small way. Instead of first admissions, we used the annual data on all tuberculous admissions to sanatoria in Ontario.* As far as our project is concerned, this measure of tuberculosis incidence (or morbidity) is even better than the conventional one. We are interested in measuring the annual loss to society in terms of output foregone because of tuberculosis morbidity. We should, therefore, take account of all patients admitted to tuberculosis sanatoria in any given year whether they are new cases or reactivated cases, i.e., whether they

*It should be pointed... (continued on the following page)

Continuation of footnote * from page 140

...out that in the late 50's there started a trend towards treating some tuberculosis patients at home. A chemotherapy regimen was prescribed for these patients and they were expected to follow it. The data on the number of such patients are not available and, therefore, they are not dealt with in our study. It could be argued that this would impart an upward bias to the estimated benefits of the program. This is because the estimates of reduced morbidity (projected cases minus actual cases) will be upward biased as in the base-line years, used for projections, almost all patients were being hospitalized but in the later years of our study some patients were being treated outside sanatoria. However, this argument would have been valid had these out-of-sanatoria-patients been under treatment but not doing their jobs. The very fact that they are treated at home shows that their condition is not serious and most of the time they are allowed to remain on the job. It is the TCP which has made this thing possible and, therefore, the earnings of such people should be counted in estimating the benefits of the program. Our measure of B_2 does this though indirectly.

are first admissions or readmissions.* Moreover, in the recent publications of the Tuberculosis Prevention Branch, Ontario Department of Health, morbidity (or incidence) has been defined in the broader sense so as to include both new active and reactivated cases.¹⁰ It was from this branch, as indicated below, that we obtained data on tuberculosis morbidity in Ontario for the later part of the period of our study.

Total tuberculous admissions as reported in the Statistics Canada reports, "Tuberculosis Institutions in Canada,"** contain tuberculous first admissions, readmissions, and "reviews in".*** The patients in the last category will constitute a double counting and, therefore, should be deducted from our measure of tuberculosis incidence. But it was not always possible to adjust the data because we could not get information as to what percentage such patients formed of the total tuberculous admissions, let alone of tuberculous admissions by age and sex. Any possible overestimate of B_2 introduced in our calculations as a result of the inclusion of "reviews in" in our data on tuberculosis

*A readmission is a patient admitted to a tuberculous institution who had previously been discharged from such an institution. The reason for readmission is almost always the reactivation of disease. See DBS, Tuberculous Statistics, 1955 (Ottawa: Dominion Bureau of Statistics), p. 5.

**In 1953, the title of this publication was changed to Tuberculosis Statistics.

***Review in is defined as a patient who is readmitted, but is found to have no active tuberculosis and is, therefore, discharged within 30 days.

morbidity will be of a small order of magnitude. For example, we estimated that "reviews in" in 1945 to 1947--the years for which we could prepare some estimates--were about 1% only of the annual total admissions* to tuberculosis institutions during those years.¹¹

The age-sex specific data on tuberculosis incidence, even for the modified definition (though for our purposes better than the conventional one) adopted by us, are not available from Statistics Canada reports for the years 1954 and onwards. For 1960 and 1961, the data are taken from the respective annual reports of the Tuberculosis Prevention Branch on the epidemiology of tuberculosis in Ontario. To get data for other years we approached the Epidemiology Service, Ontario Department of Health. Dr. M.J. Ashley** of this service helped us and provided the data for 1962 to 1966 inclusive. She, however, could not find the required data for 1954-1959 inclusive.

To develop the data for these years, we considered using linear interpolation. But when we drew the scatter diagrams, it became obvious that a linear function would not give a good fit, nor would a non-linear function for that matter. And to draw a line by hand would have been highly

*By total admissions we mean a total of both tuberculous and non-tuberculous admissions to sanatoria. Tuberculous admission is defined as a patient admitted to a tuberculous institution, during the current year, who was diagnosed on admission to have active tuberculosis.

**Dr. Ashley is the Medical Officer in charge of the Chronic Disease Section of the Epidemiology Service.

subjective. Fortunately for us, however, for these years, we could extract statistics on total tuberculosis first admissions and readmissions by sex in Ontario from Statistics Canada publications.¹² To find their age-distribution, we made the assumption that for these years the age-structure of tuberculosis cases (first admissions plus readmissions) in Ontario was the same as it was for the whole of Canada.

(b) Some Negative Values of Reduced Morbidity

Estimated R_n values for some age-groups for some years turned out to be negative, i.e., for these age-groups the actual tuberculosis cases were more than the projected ones. These results are not perverse, though they may appear to be so. On the contrary, they conform to the historical realities of tuberculosis morbidity with respect to age. It is a well known and a very well documented fact that in Ontario and for that matter in almost all advanced parts of the world tuberculosis incidence has been undergoing a marked shift towards older age groups.¹³ It is our contention that it is this shift-phenomenon in tuberculosis morbidity which is responsible for these negative statistics on R_n .

Projections, we may repeat, were done by using a constant incidence rate for each age-group and sex. In each case it was given by a weighted average of the appropriate rates for a period of three years: 1945 to 1947. The weights used were the population of Ontario for each sex and the appropriate age-group in each of the three years. The rates of incidence during these years for older ages must have been

lower, because of the shift-phenomenon, than the rates obtained during later years and hence the actual tuberculous cases in these age-groups were more than the projected. This in turn resulted in negative figures for R_n . Even if the rates were higher during 1945 to 1947, they must not have been so much higher, because of the shift in the disease to older ages, as to make the projected cases more than the actual.

If our hypothesis explaining the negative statistics on R_n is right then with the temporal shift of tuberculosis incidence to older and older age-groups, the R_n figures (negative) must also move accordingly. This is exactly how the R_n values behave. Take, for example, these figures for males. To begin with, we find that they are negative for ages 35 and older. By 1952, values for age-group 35 to 44 years become positive though they remain negative for ages 45 and older. In 1954, values for age-group 45 to 54 also become positive and the negative values shift to ages 55 years and more. In 1960, negative values are obtained only for ages 70 years and older. They remain confined to this group for the rest of the period of our study. A similar movement of negative R_n statistics towards older age-groups over the entire period of our project was also evident in the case of incidence of tuberculosis among females.

The pertinent question, however, is why this increased morbidity (representing both new active and reacti-

vated cases* of tuberculosis) in older age-groups? It cannot possibly be explained by relapses (i.e., reactivated cases). We do not have much detailed information on reactivations in Ontario. But whatever evidence is available suggests that relapses as a proportion of total active cases found in a year have been on the decline. It has been estimated that in Ontario reactivations formed about thirty-three per cent of the total active cases in the pre-chemotherapy years. This figure decreased to about twenty per cent in 1955 and remained constant at the level up to 1963. Since then it has been falling again at a small but steady rate.¹⁴ It can be argued that the reactivation rate may increase with age and hence may contribute to an increased number of active cases in older age-groups. But it does not seem to be a valid argument. The probability of relapse, we believe, should be affected by the adequacy of treatment during the previous active episode and not by the age of a patient. Statistics on relapse-probabilities strongly suggest that our hypothesis is correct. It has been estimated that in Ontario, the annual risk of reactivation in persons with previous history of active tuberculosis is 1:90 if they had inadequate drug treatment. This risk declines drastically to 1:769 if the treatment was adequate.¹⁵ We, therefore, come to the conclusion that increased morbidity of tuberculosis among the

*The reactivated cases are defined as those cases which are known to have had a previous history of active tuberculosis. These cases, therefore, arise from a stock of cured cases present in a country.

older ages can only be explained by the increased incidence of new cases among these ages.

New cases (or first-time cases as opposed to relapses) must come from the infected* population in the country. Tuberculosis is an infectious disease but the infection in itself is benign, i.e., only a part of the infected population develops the disease or in other words infection does not necessarily lead to the development of the disease. The infected part of the population in a country can be divided into two groups: (1) recently infected and (2) with infection of long standing.

It was widely believed at one time that most of the new cases generally arose from recent infections. People infected with tubercle bacillus (a bacterium that is the cause of tuberculosis) for a long time were supposed to acquire resistance to the disease and thus the healthy tuberculin reactors (for whom the tuberculin test is positive) were believed not to be the major source of new cases. But the recent studies have shown that this is not correct. In fact it is these people who are the main source of new cases in countries with advanced tuberculosis control programs. In countries like the U.S.A. and Denmark as much as about three-quarters of the new cases arise from recrudescence of old infections.¹⁶ The prevalent medical opinion on the subject has best been summarized by Feldmann, medical director of

*For the definition of tuberculosis infection see supra, p. 80, n.

the U.S. National Tuberculosis Association. In explaining the morbidity of tuberculosis in the United States in 1952, he made the following observations:¹⁷

...the seemingly paradoxical present-day peak of morbidity in late life does not represent an increasing risk with age but is a reflection of a higher prevalence of infection which in turn is the residual of higher rates in earlier times...since decreasing infection rates are mirrored in morbidity rates many years later in life, it is difficult to escape the conclusion that endogenous or old infections must be the major source of new active cases.

In addition to this generally accepted source of new cases, we should note two more equally important findings reported in the medical literature on tuberculosis. First, it has been found that the infection rates in countries with advanced tuberculosis control programs have been falling and have reached quite a low level.¹⁸ Second, this steady fall in infection rates can be directly attributed to a large extent to the intensification of control programs (case finding, isolation and treatment of active cases of the disease) in these countries.¹⁹

Putting all the above facts together, we are justified in concluding that the negative statistics on R_n , which steadily shifted to older age groups during the period under study, resulted from an absence of an intensified and extended TCP in Ontario in pre-1948 years. Had there been as intensive and effective a program as has been in operation since 1948, the risk of catching tuberculous infection would have been less than it actually was. This would have reduced the number of people who became infected and later in their old

age became a major source of new tuberculous cases in Ontario. This in turn would have decreased the number of cases detected in these age groups in the post-1948 era when the efforts at case finding and treatment were very much intensified under the new extended TCP in Ontario. Actual cases in these age-groups would have been less than the projected and R_n would have had positive values.

In other words we can say that the negative values for R_n result from (1) the persistence of infections acquired in the past; (2) better methods of diagnosis, detection and treatment; (3) increased facilities for their use provided by the "Extended Tuberculosis Control Program" and (4) the control of new infections under the new program. These negative statistics, therefore, are an indication of the success of the TCP in Ontario since 1948. These figures should not be allowed to affect negatively the estimated value of the benefits of the program. However, to replace these negative data by some positive numbers will be highly arbitrary. We decided to substitute zero for each negative value of R_n . This is the most conservative estimate and will introduce a downward bias in our calculations of the benefits of the program. But this is the approach, as mentioned earlier (see supra, p. 75), that has been followed throughout this study.

B. Other Data

The only other data that we need now in order to calculate B_2 are on Y_n (average annual earnings by age) and

H (average period of disability). The statistics on the former are the same as used for calculating the discounted value of life-time earnings of a person. For the latter, as already mentioned (see supra, p. 99), we use the figures on mean hospital stay of tuberculous patients in Ontario. These are taken from the Statistics Canada report.²⁰ One point which we might mention here is that in 1966, Statistics Canada substantially changed the format and the contents of its report on tuberculosis statistics. It stopped publishing data on mean hospital stay of patients in Canada and provinces. We, therefore, assumed that the mean length of stay in 1966 was the same as in 1965 and this, we believe, is quite a reasonable assumption.

C. Estimated Values of Benefits from Reduced Morbidity -- B_2

We could now use formula (4.4) to calculate B_2 . Again, as in estimating B_1 , we used the data for each sex for given age-groups rather than for age by single year. The groups used were 15-24, 25-34, 35-44, 45-54, 55-69 and 70 or more years. They were decided largely on the basis of the age-groups for which the statistics on tuberculous patients were available and on the assumption that people of ages less than fifteen years generally are not in the labour force and, therefore, have no earnings.

The results of our calculations are reported in Table 5.10 for three representative years: 1948, 1957 and 1966.

TABLE 5.10

BENEFITS FROM REDUCED TUBERCULOSIS MORBIDITY DISCOUNTED TO 1948
ONTARIO, 1948, 1957, and 1966.

(Current Dollars)

Year	Rates of Discount Used		
	4%	8%	15%
MALES			
1948	65,978	65,978	65,978
1957	1,930,641	1,374,636	781,127
1966	2,925,806	1,483,262	478,945
FEMALES			
1948	5,180	5,180	5,180
1957	1,025,622	730,254	414,961
1966	1,552,376	786,991	254,119

Source: See Text.

1.3 Total Benefits of the Program

Total benefits of the TCP in Ontario from 1948 to 1966 are given simply by the summation of B_1 and B_2 . Estimates of these total benefits for each year have been presented in Table 5.11.* Table 5.12 reproduces the same results in real terms. For converting the current dollar values into real terms the same time series of consumer price index was used as for calculating the discounted lifetime earnings. These results very clearly show that the value of total benefits decreases very sharply as the discount rate used increases. Total benefits in real terms are about \$489 million when the rate of interest used for discounting is four per cent. As the rate is raised to eight per cent, the value of benefits falls to about \$217 million. It declines still further to about \$80 million when the discount rate is increased to fifteen per cent.

2. Costs of the Program

Our efforts should now be devoted to calculating the marginal costs** of the tuberculosis control program (TCP) in Ontario from 1948 to 1966. There are no doubt some data problems to be faced. But it will become clear to the reader as he moves on that we are able to produce a reliable time series of the estimated costs of the TCP in Ontario. Other estimates have been produced in the past for 1948 and

*It could be argued... (continued on the following page)

Continuation of footnote * from page 151

...that our use of average earnings in estimating the benefits from reduced mortality and morbidity would bias our results upwards. This is because tuberculosis generally may have higher mortality and incidence rates among such people as belong to the lower stratum of society and hence have less than average earnings. Their earnings in all probability will be nearer to the first quartile of the income distribution. There seems to be some merit in this argument. But given the present state of data availability, there does not seem to be any way to take account of this social aspect of the disease.

**For the definition of marginal costs, see supra, p. 9.

TABLE 5.11
 MARGINAL BENEFITS OF THE TUBERCULOSIS CONTROL PROGRAM DISCOUNTED TO 1948
 ONTARIO, 1948 TO 1966
 (Current Dollars in Thousands)

Year	Males			Females			Total*
	4% (1)	8% (2)	15% (3)	4% (4)	8% (5)	15% (6)	
1948	5,773.5	3,424.6	1,964.2	1,309.4	802.2	475.1	7,082.9
1949	10,551.1	6,326.4	3,600.4	1,752.1	1,068.8	612.8	12,303.3
1950	13,982.2	8,168.2	4,393.6	2,042.5	1,194.5	639.3	16,024.6
1951	14,252.7	7,999.5	4,054.2	2,608.9	1,472.1	748.3	16,861.6
1952	19,299.3	10,626.7	5,188.4	3,626.8	1,994.8	971.3	22,926.1
1953	22,915.0	12,210.3	5,611.8	3,831.3	1,999.1	894.0	26,746.2
1954	23,290.4	12,128.1	5,385.6	4,779.0	2,542.7	1,171.5	28,069.4
1955	25,330.8	12,758.8	5,346.0	5,140.1	2,562.6	1,072.1	30,470.8
1956	27,896.8	13,605.8	5,355.1	6,110.0	2,985.8	1,202.5	34,006.9
1957	28,113.3	12,922.4	4,693.8	6,748.5	3,158.7	1,207.1	34,861.8
1958	29,919.4	13,364.8	4,615.8	7,260.1	3,306.4	1,205.1	37,179.5
1959	31,935.6	13,885.7	4,571.8	7,950.1	3,519.8	1,223.6	39,885.7
1960	33,097.9	14,020.2	4,409.0	8,758.0	3,799.7	1,264.3	41,855.9
1961	33,760.0	13,612.3	3,954.9	9,180.3	3,720.4	1,121.1	42,940.3
1962	32,801.1	12,649.0	3,418.1	9,060.8	3,473.1	961.3	41,861.9
1963	33,399.0	12,380.5	3,125.3	9,499.4	3,470.3	891.4	42,898.5
1964	33,442.1	11,920.1	2,827.5	9,662.7	3,416.3	826.3	43,104.8
1965	34,120.1	11,739.4	2,624.6	10,695.5	3,605.1	812.5	44,815.6
1966	35,868.3	11,903.7	2,501.6	11,268.3	3,690.1	785.3	47,136.6
Total*	489,748.7	215,646.5	77,642.0	121,283.8	51,782.4	18,084.7	611,032.5

* Row and Column totals may not add because of rounding.

Source: See Text

TABLE 5.12

MARGINAL BENEFITS OF THE TUBERCULOSIS CONTROL PROGRAM DISCOUNTED TO 1948

ONTARIO, 1948 to 1966

(1949 Dollars in Thousands)

Year	Males			Females			Total*		
	4% (1)	8% (2)	15% (3)	4% (4)	8% (5)	15% (6)	4% (7)=(1)+(4)	8% (8)=(2)+(5)	15% (9)=(3)+(6)
1948	5,952.1	3,530.5	2,024.9	1,349.1	827.0	489.8	7,302.0	4,357.5	2,514.7
1949	10,551.1	6,326.4	3,600.4	1,752.1	1,068.8	612.8	12,303.3	7,395.2	4,213.2
1950	13,588.1	7,937.9	4,270.0	1,984.9	1,160.8	621.3	15,573.0	9,098.8	4,891.3
1951	12,535.3	7,035.6	3,565.7	2,294.6	1,294.7	658.1	14,829.9	8,330.3	4,223.9
1952	16,565.9	9,121.6	4,453.6	3,113.1	1,712.3	833.8	19,679.0	10,833.9	5,287.3
1953	19,839.8	10,571.7	4,858.7	3,317.1	1,730.8	774.0	23,156.9	12,302.5	5,632.7
1954	20,043.4	10,437.3	4,634.8	4,112.8	2,188.2	1,008.2	24,156.1	12,625.5	5,642.9
1955	21,761.8	10,961.2	4,592.8	4,415.9	2,201.6	921.0	26,177.7	13,162.7	5,513.8
1956	23,621.4	11,520.6	4,534.4	5,173.6	2,528.2	1,018.2	28,795.0	14,048.7	5,552.6
1957	23,062.6	10,600.8	3,850.5	5,536.1	2,591.2	990.3	28,598.7	13,192.1	4,840.8
1958	23,916.4	10,683.3	3,689.7	5,803.4	2,643.0	963.2	29,719.9	13,326.2	4,653.0
1959	25,245.6	10,976.8	3,614.1	6,284.7	2,782.5	967.2	31,530.2	13,759.3	4,581.3
1960	25,857.7	10,953.3	3,444.5	6,842.2	2,968.5	987.7	32,699.9	13,921.8	4,432.3
1961	26,130.1	10,535.8	3,061.1	7,105.5	2,879.6	867.7	33,235.5	13,415.4	3,928.8
1962	25,096.5	9,677.9	2,615.2	6,932.5	2,657.3	735.5	32,029.0	12,335.3	3,350.7
1963	25,112.0	9,308.6	2,349.9	7,142.4	2,609.2	670.2	32,254.4	11,917.9	3,020.1
1964	24,698.8	8,803.6	2,088.2	7,136.4	2,523.1	610.3	31,835.2	11,326.7	2,698.5
1965	24,599.9	8,463.9	1,892.3	7,711.3	2,599.2	585.8	32,311.2	11,063.1	2,478.1
1966	24,925.8	8,272.2	1,738.4	7,830.6	2,564.3	545.7	32,756.5	10,836.5	2,284.1
Total*	393,104.3	175,719.1	64,879.3	95,839.1	41,530.3	14,860.8	488,943.4	217,249.4	79,740.1

*Row and Column totals may not add because of rounding

Source: See Text

1952.²¹ Our estimates, however, are more comprehensive and cover the entire period 1948-1966 (see infra, pp. 163-166).

Marginal costs of the program are determined by using formula (4.6). For this purpose we have to first prepare the estimates of the total costs for each year from 1945 to 1966: for 1945-1947 to project the total costs in the absence of the program and for the rest of the period to calculate marginal costs of the project.

2.1 Total Costs of the Program

The total costs of the TCP refer to all the costs in Ontario of case finding, providing treatment and care for patients and doing research on the use of chemotherapy.* Their estimates, as mentioned earlier, are obtained by summing the costs incurred by all the agencies, institutes and organizations involved in the program (see supra, p. 101). There is the problem of fund-transfers among the various agencies and every effort is made to avoid double counting.

A. Public Sanatoria Costs

The public sanatoria** in Ontario, as distinct from the federal sanatoria, were the main institutions providing treatment to tuberculous patients during the period

*There were no costs incurred on the discovery of "wonder drugs". They were discovered abroad.

**Sanatoria in Ontario are operated by voluntary independent boards. In all the cases, however, various levels of government, especially the provincial, provide by far the largest part of their finances.

of our study. Costs incurred for their maintenance and operations constituted the largest part of the total costs of the TCP. Statistics Canada published figures on their annual expenditures.²² These expenses cover the gross salaries and wages earned by the sanatoria personnel, value of contributed services rendered by staff members working without pay, monies spent on drugs, medical and surgical supplies, etc.

Funds to finance the sanatoria operations come from several sources. Statistics Canada provides information on these sources and their contributions to sanatoria revenues.²³ More than four-fifths of these revenues come from the government sources: federal, provincial and municipal. The most important single source is the provincial government which gives them annual grants according to the services rendered. The federal government also pays them for the care of native Indians and Veterans admitted to these institutions.* Similarly payments are made by the Workmen's Compensation Board for the treatment of its wards. The other sources of revenue are donations and bequests, income from investments and contributed services, and other miscellaneous sources like patient-fees.**

*The federal government also operates its own sanatoria and tuberculosis units in general hospitals. To the calculations of their expenditures, we will come later.

**The Ontario government pays for most of the sanatorium expenses. There is no means test but the patients who can afford may pay if they so desire. In 1953, the fees from paying patients met only about 5% of the total sanatorium expenditures in Ontario.

B. Estimated Costs of Federal Sanatoria and Tuberculosis Units

The federal government, in addition to making payments to sanatoria for the services rendered to such patients as are the responsibility of the Departments of Veterans Affairs and National Health and Welfare, also maintains its own sanatoria and tuberculosis units to give treatment facilities to its wards. Consequently, the expenses reported by the public sanatoria do not cover the total costs of tuberculosis treatment in Ontario. This fact is well recognized.²⁴ At the same time it is also recognized that it is not possible to have information on the expenses of tuberculosis units* and the federal government sanatoria.²⁵

But to ignore these costs will be to under-estimate the total costs of the TCP. We devised a method to calculate them. Annual data on "patient days" of care given by these institutions could be gleaned from Statistics Canada's reports on Tuberculosis Statistics. These reports also published figures for each province on the average cost per patient day in tuberculosis sanatoria. Assuming that the cost of serving a tuberculosis patient in a federal institution is the same as in a public sanatorium we estimated the expenses of the federal institutions by multiplying the annual data on "pat-

*A tuberculosis unit is a tuberculosis section of a larger hospital. Unlike a sanatorium, it does not maintain its own personnel and financial accounts. They are amalgamated with the accounts for the hospital as a whole.

**They are defined as the total days of care given to in-patients.

ient days" and the "average cost per patient day." After we had calculated the annual costs of tuberculosis treatment provided by these institutions, we found that in 1946 Statistics Canada had also used this method to prepare estimates of the total costs of maintaining tuberculous patients in the federal hospitals.²⁶

C. Estimated Costs of Tuberculosis Treatment in Mental Hospitals

We used this method for calculating the costs of tuberculosis treatment in mental hospitals in Ontario. But we could do so only for six years: 1961 to 1966. For the rest of the years, the data on the number of total "patient days" of care devoted to treat tuberculosis found in the patients in mental institutions were not available. We considered estimating these figures (for 1948 to 1960) by fitting a trend line through the data for 1961 to 1966. But unfortunately there is no discernible trend. Figures on "patient days" in these years fluctuate too much. For example, the number of "patient days" reported for 1962 are 45,044. In 1964 they decline to 39,200, rise again to 50,143 in 1965 and fall again to 42,452 in 1966.²⁷

To include the cost estimates only for 1961-1966 will create an upward bias in the estimated marginal costs of the TCP. But then, as mentioned earlier (see supra, p. 75) we have decided to opt for the upward biased cost estimates wherever a choice has to be made.

D. Expenses of the Division of Tuberculosis Prevention

As mentioned earlier (see supra, p. 14), the province administers the TCP in Ontario through its Division of Tuberculosis Prevention, Ontario Department of Health. The Division looks after all the aspects of the TCP: prevention, treatment and rehabilitation. Expenses incurred by the Division cover a wide variety of services provided to tuberculous patients like X-ray examinations and supply of free tuberculin to clinics, etc. The data on the annual expenses of the Division are taken from the yearly reports on the public accounts of Ontario.²⁸

The expenses reported by the Division include grants given to the sanatoria in the province (1) to pay for the maintenance of patients; and (2) to partially cover the building costs of sanatoria. These grants are deducted from the annual expenses of the Division and only the residual is taken into account. To do otherwise will lead to double counting. The grants paid for the maintenance of the patients are already included in the expenditures of the sanatoria and the building grants are treated below as a separate category.

It has been previously pointed out that since 1960 rehabilitation is being looked after by a different Division (see supra, p. 14, n). But no information is available on the expenditure incurred by this new branch on the rehabilitation of tuberculous patients. So we have to ignore this cost if there was any. Even if the information were available, these expenses should be ignored. Rehabilitation is

for cured patients and, therefore, related to debility benefits. We can not measure these benefits (see supra, pp. 99-101). On the cost side also, therefore, costs incurred on rehabilitation should not be counted. Modern treatment of tuberculosis has made special measures for rehabilitation unnecessary.²⁹ Now even the Army and Navy of the United States (their work is obviously hard) return men to full duty after treatment for tuberculosis.³⁰

E. Building Grants to Sanatoria

No information is available regarding the construction costs of the sanatoria. The sanatoria expenses noted above are only the expenditures for the operation and maintenance of the sanatoria. They do not include the construction costs or other capital costs. But the data are available on the amount of grants given to the sanatoria to assist them in this respect. The building grants are given by both the provincial and the federal governments. The monies granted by the provincial government are reported in the expenses of the Tuberculosis Prevention Division. The federal government grants are provided under its "Hospital Construction Grants Program" started in 1948. They are reported in the annual expenditure statement of the Ontario Department of Health: Federal Health Grants Operating Fund.³¹

These figures, it may be noted, are not the amounts granted but the amounts actually spent under the building grant programs. These grants helped extend the sanatoria facilities available to tuberculous patients. As the exten-

sion of such facilities was an integral part of the "Extended TCP" in Ontario since 1948, we decided to include these expenses in calculating the total costs of the TCP. It may be noted that these construction costs should yield benefits long after the terminal year of the project under study, i.e. 1966; however, we ignore them because we cannot measure them. Ignoring them is in keeping with our "conservative" philosophy: by now referred to several times and thus a familiar one. We cannot leave construction costs out of our calculations of the total costs of the TCP because these resource inputs do yield benefits within our project period also.

F. National Health Grants

As mentioned earlier, the federal government introduced the National Health Grants Program in 1948. Under this program the federal government provides grants to the provinces to help them fight tuberculosis. These grants were mainly used for diagnostic and case-finding activities. They were used to provide maintenance funds and equipment for mobile and stationary diagnostic clinics and mass X-ray units. Research in the preventive and therapeutic techniques was also encouraged under this program.

Two activities which these grants helped finance deserve special consideration. A small part of these annual grants was given to the sanatoria in the province to pay for the installation of new equipment and the increase in their staff. The former type of expenditure is a capital cost and, therefore, is not included in the above noted expenses of the

sanatoria. But the latter constitutes an operating cost and is included in the sanatoria accounts. To avoid double counting, it should be deducted from the sanatoria expenses. In the absence of any information regarding the proportion of the federal grants exclusively used for this purpose, we are forced not to make any adjustments. This will give an upward bias to the estimated marginal costs of the TCP.

As mentioned earlier in Chapter I (pp. 17 and 19), a part of the federal grant money was used to provide drugs free to the patients and, therefore, must have been reported in the sanatoria accounts. To avoid double counting the following procedure is adopted.

The sanatoria expenditure accounts give information on the annual expenses incurred on drugs for the years 1960 to 1966 inclusive. These amounts are subtracted from the federal grants expenditure. For the rest of the years, 1948 to 1959, it is assumed that 22.9% of the grants were spent on the supply of drugs and the corresponding adjustments in the grant monies spent under the program are made. This percentage is an average of the proportions of grants spent on drugs in 1948 to 1953 inclusive.³² It was estimated by the National Department of Health and Welfare.

The data on the amounts of grant spent are taken from the annual reports of the Public Accounts of Ontario.³³

G. Expenditures by Voluntary Agencies

Work of almost all the voluntary agencies in the field of tuberculosis control is coordinated by the Ontario

Tuberculosis Association.* There are county and district branches of the Association. The main work of the Association is concentrated in the prevention and diagnostic areas. In these areas it supplements the work of the Tuberculosis Prevention Division. It conducts mass surveys and operates mobile and permanent chest clinics. It sends educational material to the public and takes interest in social welfare. However, the major thrust of its activities is in the case-finding field. The funds to finance its activities are raised from the annual Christmas Seal Campaign. The campaign is run separately by each branch which is also autonomous in the allocation of funds for local use. The returns, however, are reported to the head office which coordinates the branches' work. Besides this, the Association, since its inception, has been receiving an annual grant of \$5,000 from the Ontario Department of Health. Statistics on the gross Christmas Seal Campaign returns were kindly provided by (Mrs.) N. Lytle, the Office Manager of the Association.³⁴

The returns from the campaign crossed the million dollar mark in 1955 and since then have remained above it. It is assumed that the total funds thus collected and the grant provided by the provincial government are spent on the Association's program and related activities.

We did, however, have to make one adjustment. Some

*The Association was formed in 1945. Recently its name has been changed to Ontario Tuberculosis and Respiratory Disease Association: OTRDA. Its head office is located in Toronto.

of the sanatoria have their own mobile equipment and conduct surveys in the areas they serve. The local associations connected with these sanatoria have their own campaigns and the monies thus raised are reported in the sanatoria accounts as well as in the figures supplied to us by the Ontario Tuberculosis Association. The latter figures, therefore, are adjusted for such amounts. For most of the years, statistics on them are available from the sanatoria accounts. For the rest of the years, they are estimated. For the years for which the data are available, they form an almost stable proportion of the annual revenues of the sanatoria. From 1953 to 1963, a continuous span of time for which the figures are available, they constituted on average 1.6% of the total sanatoria revenue.³⁵ This relationship is assumed for other years also.

H. Estimated Values of the Total Costs

Summation of the annual costs incurred by the above agencies and institutions gives the estimated yearly total costs of the program. They are presented in Table 5.13.

2.2 Comparison With Other Estimates

The only other estimates of the total costs of the TCP, as far as we know, were prepared by Dr. G.C. Brink for the years 1948 and 1952.³⁶ For 1948, he estimated the total costs by calculating the costs of the sanatoria, clinics, post sanatorium care and the federal tuberculosis control projects, etc. For 1952, the estimates were derived by summing the costs incurred by the provincial government and other

TABLE 5.13
 TOTAL COSTS OF THE TUBERCULOSIS CONTROL PROGRAM
 ONTARIO, 1948-1966
 (Current Dollars in Thousands)

Year (1)	Sanatoria Costs* (2)	Expenses of TB Prevention Division (Excluding Grants to Sanatoria) (3)	Building Grants to Sanatoria (Provincial) (4)	Building Grants to Sanatoria (Federal) (5)	Federal Grants (Excluding Ex- penses on Drugs) (6)	Grants to OITA** by Ontario Department of Health (7)	Christmas Seal Campaign Returns (Excluding Revenue of Sanatoria from Seal Campaigns (8)	Total (9)
1948	6,779.6	412.3	-	-	548.5	5.0	529.2	8,274.6
1949	7,359.6	399.7	-	154.9	438.5	5.0	616.7	8,974.4
1950	7,671.9	449.4	43.8	302.3	364.1	5.0	584.8	9,421.3
1951	8,510.2	463.2	586.4	102.0	504.7	5.0	603.9	10,775.4
1952	8,929.2	554.7	261.4	325.0	602.8	5.0	629.3	11,307.4
1953	9,275.1	569.9	188.4	82.6	499.2	5.0	785.9	11,406.1
1954	9,588.2	586.4	80.8	55.3	509.5	5.0	843.3	11,668.5
1955	9,377.4	583.7	32.5	24.1	547.9	5.0	956.5	11,527.1
1956	9,405.0	543.5	-	-	602.2	5.0	959.3	11,515.0
1957	9,636.0	612.6	-	-	616.8	5.0	950.6	11,821.0
1958	9,535.3	586.2	22.6	111.6	630.3	5.0	1,054.8	11,729.5
1959	9,365.5	608.6	28.0	34.9	624.1	5.0	1,063.4	12,363.5
1960	8,984.1	620.4	0.9	19.5	665.5	5.0	1,068.1	11,260.3
1961	8,971.8	582.5	13.9	10.4	619.4	5.0	1,057.3	11,293.7
1962	8,920.1	597.4	59.2	25.4	596.6	5.0	1,090.0	12,115.5
1963	9,534.1	653.6	12.1	74.3	685.2	5.0	1,151.2	10,774.7
1964	7,868.8	684.9	34.2	234.3	777.1	5.0	1,170.4	10,943.2
1965	8,086.8	726.9	7.0	95.6	779.7	5.0	1,242.2	10,943.2
1966	7,854.7	787.0	4.8	-	818.1	5.0	1,224.3	10,693.9

*Includes the estimated expenses of the federal sanatoria, 1948-1966 and the estimated expenses on tuberculosis treatment in mental hospitals, 1960-1966.

**Ontario Tuberculosis Association.

-No data are available.

agencies. Under the heading "provincial government" he counted the treatment costs, capital grants to sanatoria and the expenses of the Division of Tuberculosis Prevention and some other types of expenses met by the government. Under "Other Agencies" were included the federal capital grants to sanatoria, federal health grants utilized and the voluntary Christmas seal contributions, etc. He arrived at the figures of \$7,230,000 and \$11,716,218 for 1948 and 1952 respectively. Our corresponding estimates are \$8,274,640 and \$11,307,397.

Brink did not give any information on the sources of his data or the methods of his calculations. He made no attempt to estimate the costs of treatment in the federal tuberculosis institutions. He does not explain whether any efforts were made to avoid double counting. Another important point to be considered is that his estimates include expenses made to pay "Mothers' Allowance".* In addition to this, the 1952 estimate counts the compensation for tuberculosis paid to hospital employees.**

Expenditures on these items are transfer payments and should not be counted in the social costs of the

*Under the Mothers' Allowance Act in Ontario, a mother gets allowance to support herself and her dependent children if her husband is in a sanatorium. The Act is administered by the Minister of Public Welfare. There is a means test.

**In 1950, tuberculosis was made a compensable disease for all employees of hospitals and sanatoria (see supra, p. 16).

program.*

If we subtract these expenditures from Brink's estimates, we are left with \$6,830,000 and \$11,195,572 as the costs of the TCP in 1948 and 1952 respectively.

2.3 Real Total Costs

Estimated total costs of the TCP for each year from 1948 to 1966 were changed into constant 1949 dollars. To do so the implicit price index for personal expenditure on consumer goods and services was used. The time series data on this index were taken from Statistics Canada publications.³⁸ The indexes for 1957 to 1966 inclusive were converted from 1957-base to 1949-base.³⁹ The resultant figures of the real total costs of the TCP appear in Table 5.14.

TABLE 5.14

TOTAL COSTS OF THE TUBERCULOSIS CONTROL PROGRAM
ONTARIO, 1948-1966
(1949 Dollars in Thousands)

Year	Total Cost	Year	Total Cost
1948	8,605.6	1958	9,317.9
1949	8,974.4	1959	9,031.7
1950	9,138.6	1960	8,636.2
1951	9,492.2	1961	8,652.9
1952	9,611.3	1962	8,470.2
1953	9,695.2	1963	8,965.4
1954	9,801.5	1964	7,865.5
1955	9,682.7	1965	7,769.6
1956	9,557.4	1966	7,378.8
1957	9,456.8		

*To the extent that these costs are payments for loss of earnings, they are already counted in the benefit side of the program. A part of the "compensation payments" to hospital employees covers the treatment expenses. It is already included in the sanatoria expenses.

2.4 Marginal Costs

To estimate the marginal costs of the TCP, as defined in Chapter IV, we need the projected total costs of the program that would have been incurred in the absence of the "Accelerated Tuberculosis Control Program". As already explained, two sets of the projected costs were estimated (see supra, pp. 102-103). One was computed by assuming that the total expenditure on tuberculosis in Ontario would have remained at the average level obtained in the last three years before the "Extended Control Program" was launched, i.e., 1945 to 1947. The other was calculated on the assumption that not the total expenditure but the average per capita expenditure would have remained constant at the average level reached in these three years. Marginal cost estimates based on each of these assumptions are referred to as Set A and Set B costs respectively. Their yearly values, discounted to 1948, are presented in Table 5.15.

Set B calculations produce negative marginal costs from 1959 onwards. This indicates that the program has been quite valuable in controlling tuberculosis. We no longer have to spend extra resources. From then on the reduced costs of the program are really the benefits. But we leave them on the cost side as negative costs. This is done in order to compare our results with those achieved when the 'Set A' cost projections are used.*

*The NPV (B-C) of the project, a criterion of project selection favoured in this study, will not be affected whether these negative marginal costs are left on the cost side or are transferred to the benefit side as positive benefits (cf., Ch. III).

TABLE 5.15
 MARGINAL COSTS OF THE TUBERCULOSIS CONTROL PROGRAM DISCOUNTED TO 1948
 ONTARIO, 1948-1966
 (1949 Dollars in Thousands)

Year	Set A			Set B		
	Rates of Interest Used for Discounting					
	4%	8%	15%	4%	8%	15%
1948	2,254.1	2,254.1	2,254.1	1,953.9	1,953.9	1,953.9
1949	2,521.9	2,428.6	2,280.9	2,063.5	1,987.1	1,866.3
1950	2,576.9	2,389.4	2,107.3	1,991.6	1,846.6	1,628.6
1951	2,783.2	2,485.2	2,058.4	2,102.7	1,877.6	1,555.2
1952	2,786.5	2,395.9	1,864.0	1,909.2	1,164.6	1,277.1
1953	2,748.2	2,275.7	1,662.5	1,738.0	1,439.2	1,051.4
1954	2,726.5	2,174.2	1,491.4	1,572.9	1,254.3	860.4
1955	2,531.4	1,943.8	1,252.2	1,261.0	968.3	623.8
1956	2,342.5	1,732.1	1,048.0	870.0	643.3	389.2
1957	2,181.8	1,553.3	882.8	529.7	377.1	214.3
1958	2,004.1	1,374.0	733.3	226.2	155.1	82.8
1959	1,741.1	1,149.5	575.0	-118.2	-78.1	-39.1
1960	1,427.1	907.3	427.0	-493.1	-313.5	-147.6
1961	1,382.2	846.2	374.0	-600.9	-367.9	-162.6
1962	1,223.6	721.4	299.4	-778.0	-458.7	-90.4
1963	1,451.5	823.9	321.2	-564.3	-320.3	-124.9
1964	808.3	441.9	161.8	-1,243.8	-680.0	-249.0
1965	728.1	383.3	131.7	-1,360.5	-716.3	-246.2
1966	507.1	257.0	83.0	-1,676.6	-849.8	-274.5
Total*	36,726.0	28,536.9	20,009.1	9,383.4	9,882.4	10,168.8

*Column totals may not add exactly because of rounding.

Source: See Text.

3. The Final Results

We favour the net present value criterion of project selection but we have calculated the results by using the other two criteria too, namely the benefit-cost ratio and the rate of return. In each case the results leave us in no doubt that expenditure on the TCP in Ontario from 1948 to 1966 has been beneficial to society.

3.1 Net Present Value

The net present value of the project is positive even at 15% rate of discount. Moreover, it remains so even after the benefits have been adjusted downwards to take account of the improved (medical) technology resulting from the discovery of "wonder drugs".* The results are presented in Table 5.16.

The reader may note that 'Set B' costs increase as the discount rate rises. This may seem to be unwarranted, but it is because of the fact, already mentioned, that in this case marginal costs after 1959 become negative.

3.2 Benefit-Cost Ratio

We can calculate the benefit-cost ratios of the project by using the data on the benefits and costs of the TCP given in columns 2, 3 and 4 of Table 5.16. The results are presented below in Table 5.17. It reports the benefit-cost ratios for two alternative estimates of the marginal

*The rationale for and the method of this adjustment have been discussed in Chapter IV (pp. 107-112).

TABLE 5.16
NET PRESENT VALUE OF THE PROJECT
 (1949 Dollars in Thousands)

Discount Rate (Percent)	Marginal* Benefits (2)	Marginal Costs*		Net Present Value	
		Set A** (3)	Set B** (4)	Set A** (5) = (2) - (3)	Set B** (6) = (2) - (4)
4	488,943.4	36,726.0	9,383.4	452,217.4	479,560.0
8	217,249.4	28,536.9	9,882.4	188,712.5	207,367.0
15	79,740.1	20,009.1	10,168.8	59,731.0	69,571.3
After Allowing for the Beneficial Effects of "Wonder Drugs"***					
4	175,798.9	36,726.0	9,383.4	139,072.9	166,415.5
8	79,806.2	28,536.9	9,882.4	51,269.3	69,923.8
15	30,852.3	20,009.1	10,168.8	10,843.2	20,683.5

*Discounted to 1948.

**For explanation, see p. 167.

***For explanation, see pp. 107-112.

Source: Tables 5.12 and 5.15.

costs of the project. It is clear that in each case the benefit-cost ratios for the project are greater than unity even when the benefits of the project have been adjusted downwards to allow for the beneficial effects of chemotherapy.

TABLE 5.17
BENEFIT-COST RATIOS OF THE PROJECT

Discount Rate (Percent)	Benefit-Cost Ratios With	
	Set A Marginal Costs	Set B Marginal Costs
4	13.31	52.11
8	7.61	21.98
15	3.99	7.84
After Allowing for the Beneficial Effects of "Wonder Drugs"		
4	4.79	18.74
8	2.80	8.08
15	1.54	3.03

3.3 Internal Rate of Return

A time series of the marginal benefits and two series of marginal costs, corresponding to Sets A and B of the discounted marginal costs (in tables 5.16 and 5.17), were prepared to calculate the rates of return on the project.

It should be pointed out that our rates of return estimates are not strictly internal rates of return. In calculating the benefits of the TCP, we have used the discounted values of life-time earnings. These values were calculated by using 4, 8 and 15 per cent discount rates.

We know of at least one study in the health field which calculates the rates of return that are conceptually equivalent to the rates estimated by us.⁴⁰ It was largely to satisfy our curiosity and to compare approximately our rates with the rates obtained in that study that we decided to produce our estimated rates of return.*

These rates are determined only in one case: when (1) the benefits of the TCP have been adjusted downwards to take account of improved medical technology resulting from the discovery and use of antibiotics and (2) in calculating the benefits from reduced mortality, the life-time earnings of a person have been discounted at 15 per cent. The rates are very high. Their values are 62.3 per cent and 204.3 per cent for the marginal cost estimates of the project given by Set A and Set B respectively. In all other cases the rates of return are indeterminate because in these cases the benefits of the project are greater than its costs for each year of its life. It is clear from equation (3.6) in Chapter III that under such circumstances there cannot be any real root which will solve it. Howsoever high a discount rate we may use we will always be left with one positive value, the undiscounted value of (B-C) for 1948. In other words, there will be no real rate of return.

*In his study, Weisbrod computes rates of return on polio research under several alternative sets of assumptions regarding costs and benefits. He concludes that the most likely rate of return would be about 11 to 12 per cent.

This is not something very unusual. We have already discussed such a possibility (see supra, pp. 65-66). As a matter of fact it is one of the main shortcomings, which has been well recognized in the literature, of the rate of return criterion that it may not always be possible to calculate such a rate.

The reason for this indeterminacy of the rate of return is the time profile of costs (including the capital costs). There is no lump sum investment at any stage of the project. The costs are well distributed over its entire life span. It is not a conventional investment project.* It has been well brought out in the literature that it is only in the case of conventional investments that we have a unique rate of return (see supra, p. 66). In all other cases we may get multiple rates or the rate may even be indeterminate.

We could assume that in 1948, when the "Extended Control Program" was launched there were no marginal (incremental) benefits. They started flowing in 1949 and the benefits in 1949 and the later years were attributable predominantly to increased investment in the current year but also to additional investment in the past under the new program.

If we make these assumptions the first term in equation (3.6) in Chapter III will be a negative one and we may get a real root(s) for this equation.

It should be pointed out that these assumptions are

*Conventional investment is defined as that investment which has one or more periods of net outlays followed by one or more periods of proceeds.

TABLE 5.18
RATES OF RETURN ON THE PROJECT
 (Per Cent)

Discount Rate Used for Calculating V* (Per Cent)	Marginal Costs** given by	
	Set A	Set B
4	481.8	576.3
8	270.5	332.4
15	136.5	176.4
After Allowing for the Beneficial Effects Of Wonder Drugs		
4	197.2	249.3
8	92.8	129.7
15	35.0	59.8

*present value of life-time earnings of a person.
 **Undiscounted costs in 1949 dollars calculated on the basis of two alternative assumptions (see p. 167). There was a single set of undiscounted benefits in constant 1949 dollars.

very restrictive. Firstly, there is evidence to show that the benefits started flowing as soon as the new program with the chemotherapeutic treatment was started.⁴¹ Secondly, these assumptions force us to make the already conservative benefit estimates more conservative. On the basis of these assumptions, expenses in say 1958 (or any other year for that matter) will yield benefits long after 1966, the terminal year for our study. To be exact, we should count them on the benefit side of the program. But we can not measure them and, therefore, we have to leave them uncounted.

These assumptions, however, give real values for rates of return in all the cases. They are reported in Table 5.18. As expected, they are extremely high. Even the lowest rate is 35.0%. The NPV(B-C) and B/C values on the basis of these assumptions remain very high and are reduced only marginally.

Our research has shown that the investment of extra resources in the "Extended Tuberculosis Control Program" in Ontario from 1948 to 1966 has been quite beneficial to society. Even when we do not count the incalculable gains made in human happiness and welfare and consider only the economic benefits achieved, the program turns out to be a profitable use of resources.

FOOTNOTES

¹Burton A. Weisbrod, Economics of Public Health (Philadelphia: University of Pennsylvania Press, 1961), p. 51; "The Valuation of Human Capital", JPE, 69 (October, 1961), p. 428; In some studies statistics on median income rather than median earnings have been used. For example, see Rashi Fein, Economics of Mental Illness (New York: Basic Books Inc., 1958); Burton A. Weisbrod, "Preventing High School Dropouts", in Measuring Benefits of Government Investments, ed. by Robert E. Dorfman (Washington, D.C.: The Brookings Institution, 1965), pp. 117-171.

²H.S. Houthakker, "Education and Income", Review of Economics and Statistics, 41 (Feb., 1959), pp. 24-28; M. Friedman and S. Kuznets, Income From Independent Professional Practice (New York: National Bureau of Economic Research, 1945)

³T.M. Brown, Canadian Economic Growth, a study prepared for the Royal Commission on Health Services, (Ottawa: Queen's Printer, 1965), p. 95.

⁴Ibid., pp. 96 and 84.

⁵Simon Kuznets, National Income and Its Composition: 1919-1938, Vol. I (New York: National Bureau of Economic Research, 1954), p. 22.

⁶DBS, Review of Employment and Pay Rolls, 1956, and Review of Employment and Average Weekly Wages and Salaries: 1957-67 (Ottawa: Dominion Bureau of Statistics), tables 16 and 5, pp. 59 and 37 respectively.

⁷DBS, Provincial and Regional Life Tables: 1950-52, 1955-57 and Provincial and Regional Life Tables: 1960-1962 (Ottawa: Dominion Bureau of Statistics).

⁸DBS, Consumer Price Index, January 1949-August 1952; The Consumer Price Index for Canada (1949 = 100): Revision Based on 1957 Expenditures and Prices and Price Indexes, Monthly, January, 1968 (Ottawa: Dominion Bureau of Statistics).

⁹Annually a report on Births and Marriages, etc. is presented to the legislative assembly by the Registrar General of Ontario. It is published as one of the Ontario "Sessional Papers". In recent years its name has been changed to "Province of Ontario, Vital Statistics".

¹⁰ Tuberculosis Prevention Branch, Ontario Department of Health, Epidemiology of Tuberculosis in Ontario, annual reports for 1962 to 1966 (Toronto: Ontario Department of Health).

¹¹ These percentages were calculated by us from the data taken from the annual editions of DBS, Tuberculosis Institutions (Ottawa: Dominion Bureau of Statistics).

¹² DBS. Tuberculosis Statistics, Annual reports for 1954 to 1959 (Ottawa: Dominion Bureau of Statistics).

¹³ Selman A. Waksman, The Conquest of Tuberculosis (Berkeley and Los Angeles: University of California Press, 1964), p. 213; G.C. Brink, "Tuberculosis in Ontario", CJPH, 45 (May, 1954), p. 198; E. Uehlinger, "The Morbid Anatomy of Tuberculosis in Age Groups Over 50", in XVith International Tuberculosis Conference, proceedings of the Conference (2 Vols.; New York: Excerpta Medica Foundation, 1961), I, 220; E. Larmola, "The Proportion of Persons Over 50 Among the Tuberculous", in XVIth International Tuberculosis Conference, p. 230; K. Styblo, "Identification of High Tuberculosis-Risk Groups, in connection with the Epidemiological and Clinical Study of Tuberculosis in Czechoslovakia in Collaboration with WHO" in XVIIth International Tuberculosis Conference, proceedings of the Conference (New York: Excerpta Medica Foundation, 1964), pp. 364-367; Editorial, "Prediction and Theory in Epidemiology", AJPH, 47 (October, 1957), p. 1305. It notes, among other things, that tuberculosis, "which was formerly a disease of adolescents and young adults, has now become predominantly a disease of middle-aged and older persons."

¹⁴ Tuberculosis Prevention Branch, Ontario Department of Health, Tuberculosis in Ontario, annual reports for 1966 and 1968 (Toronto: Ontario Department of Health), pp. 21 and 25 respectively.

¹⁵ Special Health Services Branch, Public Health Division, The Epidemiology of Tuberculosis in Ontario, 1970 (Toronto: Ontario Department of Health, 1971), p. 23.

¹⁶ C.E. Palmer, L.W. Shaw and G.W. Comstock, "Community Trials of BCG Vaccination", American Review of Tuberculosis, 77 (June 1958), pp. 877-907; E. Groth-Petersen, Jorgan Knudsen and Erik Wilbek, "Epidemiological Basis of Tuberculosis Eradication in an Advanced Country", Bulletin of the World Health Organization, 21, No. I (1959), p. 34; U.S. Department of Health, Education and Welfare, Public Health Service, Tuberculosis Program, "The Origin of Future Tuberculosis Cases", in The Arden House Conference on Tuberculosis (Washington, D.C.: U.S. Government Printing Office, 1959), p. 41.

¹⁷Floyd M. Feldmann, "How Much Control of Tuberculosis: 1937-1957-1977?", AJPH, 47 (October, 1957), 1238.

¹⁸C.E. Palmer, et al., "Tuberculin Sensitivity of Young Adults in the United States", Public Health Report, 71 (July, 1956) 642; U.S. Department of Health, Education and Welfare, "Prevalence of Tuberculin Sensitivity in White Male Navy Recruits, 1958-59", in The Arden House Conference on Tuberculosis (Washington, D.C.: U.S. Government Printing Office, 1959).

¹⁹J.A. Myers, et al., "Importance of Tuberculin Testing of School Children: A Twenty-Eight Year Study", JAMA, 159 (September, 1955), p. 189; Palmer, Shaw and Comstock, "Community Trials", p. 899.

²⁰DBS, Tuberculosis Statistics, annual report, 1965 (2 Vols.; Ottawa: Dominion Bureau of Statistics) I, 35.

²¹The 1948 estimate appears in G.C. Brink, Outline of Tuberculosis Programme in Ontario (Toronto: Ontario Department of Health, Division of Tuberculosis Prevention, 1950), p. 34. Estimated costs for 1952 are given in G.C. Brink, "Tuberculosis in Ontario", CJPH, 45 (May, 1954), p. 201.

²²DBS, Tuberculosis Statistics: Vol. II, annual reports for 1962-1966; Tuberculosis Statistics: Financial Supplement, annual reports for 1954-1961; Tuberculosis Statistics, 1953; Tuberculosis Institutions, annual reports for 1945-1952 (Ottawa: Dominion Bureau of Statistics). Over the years the title of this publication has been changed.

²³Ibid.

²⁴DBS, Tuberculosis Statistics: Financial Supplement, annual reports for 1955, 1957, 1958 and several other years (Ottawa: Dominion Bureau of Statistics).

²⁵DBS, Tuberculosis Statistics, 1952 (Ottawa: Dominion Bureau of Statistics), p. 18.

²⁶DBS, Tuberculosis Institutions, 1946 (Ottawa: Dominion Bureau of Statistics), p. 7.

²⁷DBS, Tuberculosis Statistics: Vol. II, annual reports for 1962, 1964, 1965 and 1966 (Ottawa: Dominion Bureau of Statistics).

²⁸Government of Ontario, "Statement of Expenditure, Tuberculosis Prevention Branch, Ontario Department of Health", in the annual reports: Public Accounts of the Province of Ontario (Toronto: Queen's Printer).

²⁹V.H. Springett, "Tuberculosis Control in Britain: 1945-1970-1995", Tubercle, 52 (June, 1971), 145.

³⁰Waksman, The Conquest of Tuberculosis, p. 199.

³¹Government of Ontario, "Statement of Expenditure, Federal Health Grants Operating Fund, Ontario Department of Health", in the annual reports: Public Accounts of the Province of Ontario (Toronto: Queen's Printer).

³²Research Division, Department of National Health and Welfare, Tuberculosis Services in Canada (Ottawa: Department of National Health and Welfare, 1955), p. 11, table 3.

³³Government of Ontario, "Statement of Expenditure, Federal Health Grants Operating Fund", in Public Accounts of the Province of Ontario.

³⁴(Mrs.) N. Lytle, Personal correspondence.

³⁵DBS, Tuberculosis Statistics: Vol. II and Tuberculosis Statistics: Financial Supplement. Several annual reports.

³⁶Brink, Outline of Tuberculosis Programme in Ontario, p. 34 and "Tuberculosis in Ontario", p. 201.

³⁷Research Division, Department of National Health and Welfare, Mothers' Allowance Legislation in Canada (Ottawa: Department of National Health and Welfare, 1955), pp. 49-50.

³⁸DBS, National Accounts, Income and Expenditure: 1926-1956, Table 6, pp. 36-37; National Accounts, Income and Expenditure by Quarters, 1947-1961, Table 19, pp. 74-77; National Accounts, Income and Expenditure, 1965, Table 6, p. 20 and National Accounts, Income and Expenditure, 1966 (Ottawa: Dominion Bureau of Statistics).

³⁹A brief description of the methods of conversion can be found in DBS, Prices and Price Indexes, January, 1969 (Ottawa: Dominion Bureau of Statistics), p. 20.

⁴⁰ Burton A. Weisbrod, "Costs and Benefits of Medical Research: A Case study of Poliomyelitis", JPE, 79 (May/June, 1971), pp. 527-544.

⁴¹ Godias J. Drolet and Anthony M. Lowell, "Whereto Tuberculosis: The First Seven Years of the Antimicrobial Era, 1947-1953", American Review of Tuberculosis and Pulmonary Diseases, 72 (October, 1955), p. 442.

APPENDIX A

SOCIAL DISCOUNT RATE

What social discount rate (SDR) should be used in discounting the benefits and costs of a program to their present value is one of the most contentious issues among professional economists. The voluminous literature existing on it and its growing size bears ample testimony to this statement.¹ The main reason for this controversy is that the choice of a discount rate for government projects has a significant bearing on a number of important questions of public interest.²

1. How much should be the total investment, both public and private, in the economy?
2. How should this total investment be divided between the public and private sectors?
3. Given the level of public investment how should it be allocated among different projects.*

The whole controversy about the proper SDR can be viewed at two different levels: (1) conceptual; and (2) empirical.

At the conceptual level, the controversy is about

*As far as issue no. 3 is concerned, it can be considered at several levels of disaggregation. For example, we can study how the total public investment should be divided among different activities, say education and health or given the total investment for health services, how should it be distributed among different health projects. As far as the second type of question is concerned, we have already discussed it in some detail in Chapter III.

what the SDR should reflect; more specifically should it represent society's (or Social) time preference (STP) or the social opportunity cost of capital (SOC) used in the public project? At the empirical level, the controversy is about the proper magnitude (or size) of the SDR, whatever it may depict.

1. Controversy at the Conceptual Level

Taking first the conceptual aspect of the controversy, it will be useful to begin with the definitions of the two concepts involved in it. Social time preference (STP) expresses the society's marginal rate of substitution as consumers between consumption now and consumption in future.³ And the social opportunity cost of capital (SOC) can be defined as the value to society of the production (or consumption) which the capital used in the project would have generated in the next best use had it been put there.⁴

1.1 Market Rate of Interest

To put the whole controversy (about what the SDR should represent) in the right perspective, it will be very helpful to understand the market solution of this problem. Take an economy working under perfect competition with all its attendant assumptions of a perfect capital market, no restrictions on entry to or exit from any type of business, perfect mobility of factors of production, perfect knowledge, no externalities and so on. In such a situation, the rates of return on all alternative investments of comparable risk

will be equal, at least at the margin. Moreover, because every individual will have unrestricted access to the capital market, he will adjust his consumption policy (or the distribution of his current income between consumption and saving) through borrowing and lending in such a way that his subjective (or private) rate of time preference* will be equal to the common rate of return on private investment. It will also be equal to the social time preference rate, if an overall optimality in the allocation of resources is to be achieved. The market rate of interest, under such circumstances, becomes a rate which reflects the opportunity cost of capital (in the sense of marginal productivity of capital in the private sector) and the STP and, therefore, should be used for calculating the NPV or B/C of social projects.

The market, however, does not have one common rate of interest. There prevails, at any time, a spectrum of rates of interest. Which one is to be selected? This phenomenon of multiplicity of market rates of interest can be explained by arguing that the different rates in the market reflect the differences in riskiness of the investments. The pure rates of interest (i.e., the rate of return on private investment corrected for risk) are really the same. This pure rate of interest is commonly taken to be the rate offered on government bonds of long maturity. But even within the broad con-

*Subjective time preference measures an individual's marginal rate of substitution as a consumer between consumption now and consumption in future. It is expressed freely by him in the capital market through his consumption and saving behaviour.

text of long-term, the bonds will differ with respect to their maturity and hence with respect to the rates offered on them. It is, therefore, suggested that the market rate of interest will be represented by an average of long-term government bond rates and it is this average rate which should be used for discounting the benefits and costs of public projects.

This conventional view about the proper SDR still has its adherents, especially in government circles. For example, the U.S. Senate Document 97, providing congressional guidance on discount rates under certain circumstances, states that the discount rates "shall be based upon the average rate of interest payable by the Treasury on interest-bearing marketable securities of the United States outstanding at the end of the fiscal year preceding such computation which, upon original issue, had terms to maturity of 15 years or more."⁵ On the basis of this formula the rate provided by the Treasury Department of the U.S., for use in evaluating public projects, in the early sixties was 3 1/8 per cent.⁶ This procedure of calculating the long-run bond rate of return was criticized by the Treasury Department itself. The Treasury had not been consulted while the above formula was adopted. Douglas Dillon, the then secretary of the Treasury had the following to say on the proper SDR:

In this Department's judgement the interest rate most appropriate for both cost-benefit analysis and the determination of reimbursement and cost saving arrangements should reflect the Government's current borrowing costs and, therefore, should be determined on the basis

of current market yields on outstanding long-term Treasury obligations. At the present time, the market yield on long-term obligations is close to $4\frac{1}{4}$ per cent.⁷

Though the rate calculated by the formula given in the U.S. Senate Document 97 and the rate recommended by the Treasury Department differ in magnitude, at the conceptual level both represent the view that the appropriate SDR is given by the market interest rate on long-term government bonds. Other examples of this conventional view of the proper discount rate for government projects can be found too.⁸

But the use of the market rate of interest as the appropriate SDR has been criticized by both the social time preference school of thought and the social opportunity cost of capital school. The former thinks that it is too high a rate whereas the latter believes that it will be too low.

1.2 Social Time Preference Rate

Some economists believe that the market rate of interest based on consumer sovereignty for intertemporal choices is too high a rate to be used for evaluating social projects. According to them, even in a perfectly competitive capital market the social time preference (STP) rate will be distinct from the private time preference (PTP) rate. The former will generally be lower than the latter.

The traditional argument given for this line of thinking is that an individual takes a "myopic" view of the future and possesses a "defective telescopic facility" which makes him consume more in the present and save (and invest)

less. His view about the future is tinted by his own mortality and uncertainty about the things to come in the distant future. If we use the market rate for finding the NPV or B/C of social projects, we will be investing less for the well being of the future generations. But society has a responsibility towards the unborn as it is a continuous entity. This permanence and continuity of society, so the argument runs, is represented by the government. The government, therefore, should not discount consumption by future generations as heavily as an individual will and hence the marginal rate of discount used by the government ought to be lower than that represented by the market rate of interest. This argument was first given by Pigou and later developed by various other writers including Dobb and Tobin.⁹

This argument in favour of the STP rate has been criticized on various accounts. It is pointed out that if we believe in growthmanship,* and that is what the argument in essence implies, then a better policy may be to encourage all investment, public as well as private, through appropriate fiscal and monetary policies and to keep interest rates low for all investors whether they happen to be in the public or private sector. It is argued that the use of low discount rate on social projects as an instrument for increasing investment for the future and thus stimulating a higher growth rate in the economy may not necessarily succeed in its purpose.¹⁰

*Growthmanship can be defined as an advocacy of such policies as encourage more savings (less consumption) and investment in the present in order to have more consumption in the future.

It may simply, given full employment of factors of production in the economy, transfer resources from the private investment to the public investment sector and in doing so it will change the composition of output available to future generations, not necessarily in the direction to be desired by the unborn. Even if the product mix is altered in the desired direction, it is argued, this may be achieved by more efficient and less expensive ways. Stockfish demonstrates this point in connection with land reclamation projects.¹¹

But the entire area of growth theory -- what factors contribute to it more, what are more efficient ways of achieving a higher rate of growth and in the context of what types of economies (developed or developing) -- is in itself a controversial one and we do not intend to enter that debate as it is not relevant for our dissertation.

In any case, Marglin takes up the above argument that both types of investment, public and private, should be discounted at the same low rate of discount. He attempts to prove that the appropriate rate of discount for all investment is the STP rate and that the optimum investment in the economy will be achieved when marginal social rate of discount (or STP rate) rather than the market rate of interest (or PTP rate) is equal to the marginal productivity of investment.¹² However, he rejects the Pigovian argument as an authoritarian one. He rightly interprets it to mean that social welfare is a function of not only the utilities of the present members of society but also of those who will be its members in the

future. But then he asserts that he wants "the government's social welfare function to reflect only the preferences of present individuals" because, according to him, "a democratic government reflects only the preferences of the individuals who are presently members of the body politic."¹³

It may be possible to argue with Marglin's assertion about the function of a democratic government with regard to intertemporal choices.¹⁴ But that is not the issue at hand at present. Even if we accept Marglin's assertion, his position on the SDR is the same as that of Pigou, namely that an appropriate SDR will be different from the market rate of interest. His dispute with Pigou lies in supplying the theoretical reasons for it. His explanation is contained in what he has called the "interdependence answer".* He makes the assumption that every individual's satisfaction depends on the consumption of other individuals, both present and future, and also on his own consumption. Because of this psychic external effect between one individual's consumption and the other's satisfaction,** it can be shown that no one, taken

*Marglin has also considered another reason for STP being different from PTP. He calls it the "Schizophrenic Answer". According to this answer an individual plays a dual role. He has one rate of time preference as an individual, an economic man, but a different one as a citizen. Marglin is sympathetic to this view but he does not accept it because he finds it difficult to decide which of the two preference rates is the "true" one. Carl Landauer has recently commented on Marglin's dilemma when faced with the "Schizophrenic Answer" to the problem of STP vs PTP and has stated that Marglin feels uncomfortable about it without any good reason.¹⁵

**Marglin has argued that because of psychic externalities investment can be regarded as a public good - a good psychically consumed simultaneously by every member of society.

individually, will be willing to invest for the sake of future generations; though everyone would like others to invest. However, everyone might be willing to invest on condition that others also do so. Thus there arises an apparent conflict between our unilateral preferences and our collective preferences. The market provides no solution to this problem, only the coercive power of the state can take us out of this deadlock by forcing each one of us to invest for the benefit of future generations. This can be done by the state by discounting the social projects at the STP rate which will be lower than the market rate of interest and also by forcing the market rate itself to be equal to the STP rate. The STP rate, in Marglin's model, is basically a rate of discount reflecting a value judgement of society about a possible optimal rate of economic growth.

Lind has disputed Marglin's conclusion and argued emphatically that "interdependence effect" does not mean that the market rate of interest necessarily loses its normative significance. He further argues that "while such interdependence effects necessitate a political solution to the problem of investment, it is not, as Marglin's conclusion suggests, generally possible to effect an optimal solution simply by setting a rate of interest calculated to bring forth an 'optimal rate' of total investment."¹⁶

We have stated earlier that an advocacy of a low social discount rate is in effect an advocacy of growthmanship but the whole idea of growthmanship has been challenged by several writers like Tullock, Mishan and Stein.¹⁷ The main

criticism against it is that the future generations are going to be richer, in terms of per capita real income, than the present one. To provide for them through increased investment for the future by using low discount rates would be what Baumol has described as "a Robin Hood activity stood on its head."¹⁸ From this, it is further concluded that in general the future should be left to take care of itself and that we should refrain from trying to lower artificially the social discount rates.* Objections have been raised against the Tullock-Baumol-Mishan argument in terms of the future needs and the uncertainty of resources needed for their fulfillment. It is argued that "there may even be some doubt whether, in a true welfare sense, future generations will really be better off."¹⁹

1.3 Opportunity Cost of Capital Rate

One decisive argument, however, against the use of the STP rate for purposes of evaluating public investment projects is that such a procedure will lead to inefficient use of scarce resources. It is recognized, even by the proponents of the STP rate, that it will be extremely difficult, rather impossible, to apply the STP rate to all investment projects, social or private.²⁰ In a mixed economy like ours there will remain a discrepancy between the STP rate and the rates of discount used in the private sector. And if the social projects

*Exceptions to this general rule are recognized in the literature. For example, Baumol in his AER (1968) article mentions the case of irreversibilities where government intervention on behalf of the future generations will be required. But even in such a case he recommends selective subsidies rather than a low general discount rate as a policy instrument.

are discounted at the STP rate which is less than the discount rate used in the private sector, scarce resources will obviously be diverted from the private sector to the public sector. Such a development will in general lead to an inefficient use of resources. It is, therefore, argued that the social projects should be discounted at a rate which reflects the social opportunity cost of capital.²¹

As a matter of fact, the controversy on the proper discount rate between the STP school and the SOC school seems to us, and it has been pointed out in the literature, to result from the fact that different authors are focusing their attention on different issues involved in the selection of an appropriate SDR.*²² Those who recommend the use of the STP rate are studying the problem from the point of view of issue number 1 and the others who recommend opportunity cost rate are concerned with issue number 2. But confusion starts replacing logic when the rate ensuring optimal allocation of resources as between the present and future (issue number 1) is recommended also as a rate which will bring optimality in the distribution of resources between the private and public sector (issue number 2) and vice versa.

For an overall optimal resource allocation in an economy, the NPV or B/C of a project discounted at the time preference rate must be equal to the NPV or B/C of that project discounted at the opportunity cost rate. But as far as public

*For a list of issues involved in the choice of an appropriate SDR, see supra, p. 181.

investment is concerned, we tend to agree with Arrow's conclusion that "...in establishing criteria for a relatively limited body of investments, such as social investment will frequently be, the opportunity-cost criterion may be adequate if it can be presupposed that time preference has already been allowed to operate in the determination of the overall volume of investment and, therefore, indirectly in the determination of the rate of return on alternative investments."²³

But the controversy is far from settled. Formulations of investment criteria have been suggested by the proponents of the STP rate which, they claim, satisfy the conditions for overall optimality and take care of the criticism that the use of STP as a discounting factor will lead to inefficient transfer of resources from the private sector to the public sector. Such investment criteria have been suggested by such prominent economists as Marglin, Feldstein, Otto Eckstein, Krutilla and Steiner.²⁴ But their formulations have been severely criticized by equally prominent persons in the profession like Mishan and Hirshleifer.²⁵ The debate is still going on. It is not our intention to attempt to resolve this highly important controversy. In this section we simply wanted to discuss briefly some of the theoretical issues involved in the selection of an appropriate discount rate.

2. Magnitude of the Appropriate Discount Rate

After having shown our inclination to accept the SOC rate as the appropriate rate of discount for social pro-

jects, we now turn to the question of its measurement. What will be the size of the discount rate given by the opportunity cost of capital?

2.1 Marginal Productivity of Capital and Social Opportunity Cost Rate

One answer is that the SOC is given by the marginal productivity of capital invested in the private sector. The reasoning behind this argument is quite simple. If the funds invested in the public sector come from private investment, clearly the rate of return earned by them in the private sector will be the opportunity cost of these funds. If they come from private consumption, so the argument goes, they could well have been lent to the private sector and, therefore, the social cost of the funds remains the same. This is possible because in a perfectly competitive economy the consumer, at the margin, will be indifferent between consumption and investment. Private sector investment, under such circumstances, remains directly or indirectly a relevant alternative to any given public project and hence the marginal productivity of capital in the private sector will correctly measure the social opportunity cost of funds invested in the public sector. When the funds invested in a given public project form a part of savings of the public sector, private investment still remains a relevant though indirect alternative if the public sector savings are abundant. The government instead of investing in the public projects, which yield less than the marginal productivity of capital in the private

sector, can lend the funds to the private enterprise. Some complications, however, arise when the funds in the public sector are severely limited and the government works under strict budgetary stringency. After considering all possible cases, Harberger came to the following conclusion:

The opportunity cost of capital is best measured by the marginal productivity of capital in the private sector in virtually all cases, the only serious exception being the case of a binding budgetary constraint on the investible funds of the public sector, in which case the private sector marginal productivity of capital still remains as a lower limit to the discount rate relevant for public sector investment decision.²⁶

What then estimates the marginal productivity of capital in the private sector? Generally speaking, it will be given by the private rate of return on capital invested in the private sector. But as far as the SOC is concerned, it will be given not by the private rate of return on private investment but by the social rate of return on it. The social rate of return can be computed by adjusting the private rate of return for taxes like the corporation income tax. When the government invests in social projects, it loses tax yields which it would have received had those resources been invested in the private sector. Social projects, it can be argued, must earn a rate of return which is equivalent to the before-tax rate of return on a typical private investment, if efficient resource allocation is to be achieved.*

*Adjustments to the private rate of return should also be made for externalities if any. But for all practical purposes it may not be possible to do so objectively.

Stockfish calculated the social rates of return on capital invested in several lines of activities -- like manufacturing, mining, public utilities, and railroads, etc. -- in the private sector in the U.S.A. for a five year period (1961-1965). On the basis of his calculations he recommended that the social projects should be discounted at rates between 10 and 15 per cent. By finding a weighted average he suggested that an overall social rate of return in the U.S. economy and hence an appropriate social discount rate during 1961-'65 should have been 13.5 per cent.²⁷

2.2 Sources of Funds Approach to Social Opportunity Cost Rate

The entire argument that the SOC is given by the marginal productivity of capital is based upon one every crucial assumption, i.e., the capital and product markets are perfect and therefore it does not matter from what sources the funds are drawn for public investment. In other words it is of no significance whether the funds are raised by taxation and, therefore, primarily come from private consumption or they are raised by borrowing and hence primarily come from private savings.

Once we give up this assumption, the consumers in the private sector no longer remain indifferent (at the margin) between consumption now and consumption in future (investment) and the mode of financing the public projects becomes an important factor in calculating the SOC. This leads us to an alternative approach, known as the "sources of funds" approach,

to estimating the SOC of public funds. This approach has been followed by Eckstein and Krutilla - Eckstein in the U.S.A. and by Reuber and Wonnacott in Canada.²⁸

Eckstein makes the assumption that public projects are financed by funds raised by tax revenue and attempts to calculate the private opportunity cost of tax-raised federal funds. He calls it the social cost of federal capital. He estimates it by tracing how a tax reduction in the economy will affect consumption and investment. By using 1955 data for the United States, he found that taxes affecting consumption gave 5.79 per cent as the opportunity cost of social funds. For taxes affecting investment it was 5.44 per cent. Finally, by computing a weighted average of these two rates he concluded that the SOC of federal funds in the United States in 1955 was five to six per cent. Miller followed Eckstein's method twice, for 1949 and 1957, but only for taxes curtailing investment.²⁹ His estimated values of the SOC in these years were respectively 7 and 6.3 per cent. Miller, however, criticizes Eckstein's method and calls his procedures defective. He observes that, "an average computed according to his methodology is somewhat biased against government enterprise."³⁰ According to Miller what we need is a real rate of return" and he suggests a discounting factor of 4 to 4.5 per cent as the appropriate social rate of discount for low risk government projects and a rate between 4 and 6.5 per cent if

*The concept of real rate of return and its relevance to our study are discussed below, pp.

there are uncertainties.

Reuber and Wonnacott compute the opportunity cost of borrowed funds in Canada in 1959. Their argument is that the project under consideration, The Columbia River System, will be financed by funds raised by borrowing rather than by taxation.³¹ They first identify the various sectors of the capital market (e.g., consumption, business, and mortgage, etc.) from where the funds will be drawn and then attribute a marginal rate of return (financial) to the funds diverted from each sector. The financial rates are adjusted to arrive at the numerical estimates of the real rates. Finally, these rates are combined with the weights suggested by the authors and an estimate of the opportunity cost of capital in Canada in 1959 is calculated. According to them, it was 5.6 per cent if the borrowing was done by the federal government and 5.64 per cent if the funds were borrowed by the British Columbia government.³²

We are not aware of any other study which attempted to measure the social cost of capital in Canada. But some estimates of such a cost may be formed on the basis of the figures calculated for the U.S.A., keeping in view that (1) the rates of interest in Canada have a persistent tendency to be above the rates in the U.S.A.; and (2) historically the difference in these rates between the two countries has been on an average at a level of 0.60 per cent.³³

Eckstein stated that the opportunity cost of tax-raised capital in the U.S. in 1968 was 8 per cent. This figure

he obtained by adjusting his 1955 estimate for the current level of interest rates. He recommended a rate of 7 to 7.5 per cent as the appropriate rate of discount for social projects.³⁴

Harburger calculated the social opportunity cost of capital for funds raised by borrowing. He arrived at (in 1968) an approximate figure of 10.7 per cent. He said that his estimate could be modified, as a result of further research, by two percentage points at the most.³⁵ In 1957, Harberger had recommended 6 per cent or higher as the appropriate social discount rate. He had argued emphatically against a rate of 2.5 per cent which was most commonly used at that time by the U.S. government agencies undertaking cost-benefit analysis.³⁶

The foregoing general survey of the literature on the social rate of discount makes it quite clear that there is no consensus, not to speak of unanimity, among the economists on the question of an appropriate rate of discount for social projects: neither on its conceptual aspect, nor on its empirical measure. The analysts have, therefore, used different discount rates representing the ruling market rate of interest or a value judgement made by the analyst or two boundary rates.³⁷ We have decided to produce our results by using 4, 8 and 15 per cent rates of interest. It is assumed that 15% represents the private rate of return on capital before tax, i.e., the social opportunity cost of capital. Four per cent is taken to approximate the social time preference rate and 8% is assumed to represent approximately the

mid-point rate between the two. It may be treated as the market rate. This is the most practical approach. It will enable us to test the sensitivity of the net benefits of the program to discount rates.

3. Real Versus Financial Rate of Interest

Another point which emerges from the above survey is that over the years the magnitude of the rates of discount recommended by economists as the appropriate social discount rates has gone up. One of the reasons for this phenomenon is no doubt the inflation experienced by the countries concerned. It is, therefore, suggested that government should use the real rate of interest as a discounting factor.³⁸ The real rate of interest can be defined as the rate that has been deflated for an expected rate of inflation in the economy.³⁹

If the social opportunity cost of capital used in evaluating government projects is represented by a financial rate of interest rather than by a real rate, it is argued, many economically efficient projects may be rejected.⁴⁰ This is possible because: (1) financial rates of interest will generally contain a premium for expected rate of inflation; (2) but, as the normal practice goes, the dollar value of the future benefits and costs of a project is estimated by using the current (referring to the time when the analysis of a project is undertaken) market prices or their administrative equivalents. In other words, the constant (present) prices are used without any adjustment for expected inflation whereas the interest rates (financial) already have "inflationary dis-

count" built into them.

Two alternative methods have been suggested to deal with the problem: (1) rate of discount may itself be adjusted downwards for the expected rate of inflation; (2) money wages and prices used for computing the future benefits and costs of the project in question should be such as include a premium for expected inflation.

Which one of the two methods should be used? On this question the economists have different views. For example, Otto Eckstein favours the second method.⁴¹ But Reuber and Wonnacott have recommended the first one, largely on the grounds that it requires less computational work and uses the more familiar method of calculating benefits and costs of a project. On the whole, however, they show that both the methods yield approximately the same results.⁴²

As far as our study is concerned, we use the money wages and prices prevailing in each year of the project's life. We can do so because ours is an ex-post study. To take account of the inflation that occurred over the years, we convert the "current dollar" values of the benefits and costs of the program into 1949-constant dollars (see, supra, 151 and 166). Interest rates which we use in our calculations should, therefore, be taken as the real rates of interest.

4. Adjustment for Risk

There remains one more point which deserves our attention. It has been suggested often that the rate of interest to be used for discounting social projects should be

a rate which has been adjusted for risk involved in the project.

The net benefits expected from the project will remain uncertain and this is what is usually meant when we say that an investment is risky. It is, therefore, suggested that a risk premium should be added to the discount rate used. It will discount remote benefits progressively more heavily. Seagraves favours adding a risk premium of the order of 2 to 4%. He favours the idea of making one standard allowance for risk in the case of all public projects.⁴³

But even on this point, opinions among economists differ. For example, it has been argued that there is no need for making any allowance for risk. The government in any country invests in a large number of projects and its investment is highly diversified. Therefore, under the law of large numbers the outcome becomes pretty much certain and the marginal risk of any one project is so small that it can be ignored easily.⁴⁴

But those, like Seagraves, who favour adding a risk premium to the social discount rate argue that not doing so will be unfair to private enterprises that are not as diversified as the public sector.

Another type of argument which we come across in the literature is that raising the rate of discount is not the only way of dealing with risk. It can be taken account of by making contingency allowances for costs or by shortening the economic life of the project. We do not intend to enter

this controversy; but these points have been quite frequently brought out in the literature.⁴⁵

The question of adjusting the rate of discount upwards or making allowance for risk in any other way is not very important for our calculations. Ours is an ex-post study and we are dealing mostly with the actual costs and benefits, though projections of costs and benefits are used in order to compute the marginal benefits and costs of the program as defined in Chapter IV. Keeping this in mind we have decided not to make any adjustments for risk in the suggested discount rates which are used for calculating the NPV (B-C) or B/C of the TCP in Ontario.

FOOTNOTES

¹In addition to the works cited below, the following may be read with interest. This, however, is not intended to make the bibliography exhaustive. There are many more and equally important books and articles available on this subject. R.N. McKean, Efficiency in Government Through Systems Analysis (New York: John Wiley and Sons, 1958), pp. 74-95; Stephen A. Marglin, "Economic Factors Affecting System Design in Arthur Maass et al., Design of Water Resource Systems (Cambridge: Harvard University Press, 1962); Martin Feldstein, "The Social Time Preference Discount Rate in Cost-Benefit Analysis", Economic Journal, 74 (June, 1964), 360-279 and "Opportunity Cost Calculations in Cost-Benefit Analysis", Public Finance, 19, No. 2 (1964), 117-139; Eli Schwartz, "The Cost of Capital and Investment Criteria in the Public Sector", Journal of Finance, 25 (March, 1970), 135-142; Julius Margolis, "The Economic Evaluation of Federal Water Resource Development: A Review Article", AER, 49 (March, 1959), 96-111.

²William J. Baumol, "On the Social Rate of Discount", AER, 58 (September, 1968), 796; J.A. Seagraves, "More on the Social Rate of Discount", QJE, 84 (August, 1970), 431; Morton I. Kamien, "Interest Rate Guidelines for Federal Decision Making", in Hearings Before the Subcommittee on Economy in Government of the Joint Economic Committee, Congress of the United States, 90th Congress, First Session, 1967 (Washington, D.C.: Government Printing Office, 1967) pp. 145-149.

³James Tobin, "Economic Growth as an Objective of Government Policy", AEA Proceedings, May, 1964, p. 3.

⁴United Nations Research Institute for Social Development, Cost-Benefit Analysis of Social Projects, Report of a Meeting of Experts (Geneva: April, 1966), p. 43.

⁵Elmer B. Staats, Survey of Use by Federal Agencies of the Discounting Techniques in Evaluating Future Programs: Report to the Joint Committee, Congress of the United States, 90th Congress, Second Session (Washington, D.C.: U.S. Government Printing Office, 1968) p. 45.

⁶Robert L. Banks and Arnold Kotz, "The Program Budget and the Interest Rate for Public Investment", Public Administration Review, 26 (December, 1966), 287.

⁷Letter from Douglas Dillon to Stewart Udall, November 17, 1964, quoted in Robert L. Banks and Arnold Kotz, ibid.

⁸Two such examples are given in Arnold C. Harberger, "Survey of Literature on Cost-Benefit Analysis for Industrial Project Evaluation" (A paper prepared for the Inter-Regional Symposium in Industrial Project Evaluation, October 1965, Prague, Czechoslovakia).

⁹A.C. Pigou, *The Economics of Welfare* (Fourth Edition, London: Macmillan and Co., 1932), pp. 23-30; M.N. Dobb, *Economic Theory and Socialism* (New York: International Publishers, 1955), pp. 70-74; Tobin, "Economic Growth", p. 11.

¹⁰William J. Baumol, "On the Appropriate Discount Rate for Evaluation of Public Projects", in Harley H. Heinrich and Graeme M. Taylor, eds., *Program Budgeting and Benefit-Cost Analysis: Cases, Text and Readings* (Pacific Palisades, Cal., Good Year Publishing Co., 1969), p. 211.

¹¹Jacob A. Stockfish, "The Interest Rate Applicable to Government Investment Projects", in Heinrich and Taylor, eds., *Program Budgeting*, pp. 191-192.

¹²Stephen A. Marglin, "The Social Rate of Discount and the Optimal Rate of Investment", *QJE*, 77 (February, 1963), 95-111.

¹³*Ibid.*, p. 97.

¹⁴Tobin, "Economic Growth", pp. 11-13. Tobin makes a case for government intervention in order to increase savings and investment for increasing growth in the economy. Marglin's view is that government should not intervene on behalf of the future generations, though it may educate the present generation and make them aware of the future needs.

¹⁵Carl Landauer, "On the Social Rate of Discount: Comment". *AER*, 59 (December, 1969), 917, n. 2.

¹⁶Robert C. Lind, "Further Comment", *QJE*, 78 (May, 1964), 345.

¹⁷Gordon Tullock, "The Social Rate of Discount and Optimal Rate of Investment: Comment", *QJE*, 78 (May, 1964), 331-336; E.J. Mishan, "Criteria for Public Investment: Some Simplifying Suggestions". *JPE*, (April, 1967), 140, n. 3; Herbert Stein, "Discussion on a Paper by James Tobin", *AEA Proceedings*, May, 1964, p. 27.

¹⁸Baumol, "On the Social Rate of Discount", 800.

- ¹⁹Landauer, "On the Social Rate of Discount: Comment", p. 918.
- ²⁰Stephan A. Marglin, "The Opportunity Cost of Public Investment", QJE, 77 (May, 1963), 274-276.
- ²¹Baumol, "On the Social Rate of Discount"; Stockfish, "The Interest Rate"; Arnold C. Harberger, "Survey of Literature".
- ²²Ibid.
- ²³Kenneth J. Arrow, "Criteria for Social Investment", Water Resources Research, 1 (First Quarter, 1965), 3.
- ²⁴Marglin, "The Opportunity Cost of Public Investment", 274-289; Martin S. Feldstein, "Net Social Benefit Calculation and the Public Investment Decision", Oxford Economic Papers (March, 1964), 114-131; Otto Eckstein, Water Resource Development: The Economics of Project Evaluation (Cambridge: Harvard University Press, 1958), p. 101 and "A Survey of the Theory of Public Expenditure Criteria", in Public Finances: Needs, Sources and Utilization, edited by James M. Buchanan (Princeton: Princeton University Press, 1961), pp. 461-463; J.V. Krutilla and Otto Eckstein, Multiple Purpose River Development (Baltimore: John Hopkins Press, 1958); Peter Steiner, "Choosing Among Alternative Public Investments in the Water Resource Field", AER, 69 (December, 1959), 893-916.
- ²⁵Mishan, "Criteria for Public Investment", pp. 139-146; Jack Hirshleifer, "Comments" on Eckstein's paper in Public Finances, ed. by James Buchanan, pp. 495-501.
- ²⁶Harberger, "Survey of Literature".
- ²⁷Stockfish, "The Interest Rate" in Program Budgeting, ed. by Heinrich and Taylor, pp. 195-196.
- ²⁸Eckstein, Water Resource Development, pp. 81-104; Krutilla and Eckstein, Multiple Purpose River Development, Chapter 4; G.L. Reuber and R.J. Wonnacott, The Cost of Capital in Canada: With Special Reference to Public Development of the Columbia River (Washington, D.C.: Resources for the Future, Inc., 1961).
- ²⁹William L. Miller, "The Magnitude of the Discount Rate for Government Projects", Southern Economic Journal, 28 (April, 1962), 348-356.

³⁰ Ibid., p. 350.

³¹ Reuber and Wonnacott, The Cost of Capital in Canada pp. 24-25.

³² Ibid., pp. 26-53.

³³ Ibid., pp. 54-81.

³⁴ Otto Eckstein, "Interest Rate Policy for the Evaluation of Federal Programs", in Hearings Before the Subcommittee on Economy in Government of the Joint Economic Committee, Congress of the United States, 90th Congress, Second Session, 1968 (Washington, D.C.: Government Printing Office, 1968), pp. 50-57.

³⁵ Arnold C. Harberger, "On the Opportunity Cost of Public Borrowing", in Hearings Before the Subcommittee on Economy in Government of the Joint Economic Committee, Congress of the United States, 90th Congress, Second Session, 1968 (Washington, D.C.: Government Printing Office, 1968), pp. 57-65.

³⁶ Arnold C. Harberger, "The Interest Rate in Cost-Benefit Analysis", in Papers Submitted by Panelists Appearing Before the Subcommittee on Fiscal Policy of the Congress of the United States, 85th Congress, First Session, 1957 (Washington, D.C.: Government Printing Office, 1957), pp. 239-241.

³⁷ For the various rates of interest used by analysts, see United Nations Research Institute for Social Development, Cost-Benefit Analysis of Social Projects, pp. 45-47; Herbert E. Klarman, The Economics of Health (New York: Columbia University Press, 1965), pp. 164-166.

³⁸ Seagraves, "More On the Social Rate of Discount", p. 441; Reuber and Wonnacott, The Cost of Capital in Canada, pp. 6-12.

³⁹ Arnold C. Harberger, "A Testimony Before the Joint Economic Committee of the United States Congress", in Hearings July 30, 31 and August 1, 1968: Document 98-940 (Washington, D.C.: Government Printing Office, 1968), p. 70.

⁴⁰ This point has been explained with the help of a hypothetical example in Reuber and Wonnacott, The Cost of Capital in Canada, p. 9.

⁴¹Otto Eckstein, "A Testimony Before the Joint Economic Committee of the United States Congress" in Hearings July 30, 31 and August 1, 1968: Document 98-940 (Washington, D.C.: Government Printing Office, 1968), p. 71.

⁴²Reuber and Wonnacott, The Cost of Capital in Canada, pp. 10-11.

⁴³Seagraves, "More On the Social Rate of Discount", pp. 442-443.

⁴⁴Paul A. Samuelson, "Principles of Efficiency: Discussion, AEA Proceedings, May, 1964, pp. 93-96; K.J. Arrow, "Discounting and Public Investment Criteria", in Water Research, ed. by A.V. Kneese and S.C. Smith (Baltimore: The John Hopkins Press, 1966), p. 28.

⁴⁵Otto Eckstein, "A Survey of the Theory of Public Expenditure Criteria" in Public Finances, pp. 468-470; A.R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey" in Surveys of Economic Theory, Vol. III: Resource Allocation (Toronto: Macmillan and Co. for the American Economic Association and the Royal Economic Society, 1966), p. 171.

ABBREVIATIONS USED FOR
SOME JOURNALS

Abbreviations have been used for the names of a few of the journals referred to in the footnotes and the bibliography. These abbreviations are as follows:

<u>Name of the Journal</u>	<u>Abbreviations Used</u>
American Economic Review	AER
American Economic Association Proceedings	AEA Proceedings
American Journal of Public Health	AJPH
Canadian Journal of Public Health	CJPH
Journal of Political Economy	JPE
Quarterly Journal of Economics	QJE

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