HUMAN CAPITAL APPROACH TO ROAD SAFETY

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Thesis presented to the Department of Economics, Faculty of Social Science of the University of Ottawa, as partial fulfillment for the degree of Master of Arts.

Ottawa - Canada - 1971

ACKNOWLEDGEMENT

The author would like to express his appreciation to Professor P.J. Crabbe for his guidance throughout the preparation of this thesis. His deep interest in both the qualitative and the quantitave aspects of this study has been most helpful. However, the author alone is responsible for the views expressed and the analytical errors and stylistic infelicities which remain.

TABLE OF CONTENTS

Chapter		page
1.	INTRODUCTION	1
2.	WHAT HUMAN CAPITAL IS	8
	2.1 Introduction	8
	2.2 Classical Views and Reluctance	10
	2.3 A Note on the Pure Theory of Capital and Interest	17
	2.4 Treatment of Human Capital in National Accounts	22
	2.5 General Uses	28
	2.6 Conclusion	31
3.	HUMAN CAPITAL, AGGREGATE PRODUCTION FUNCTIONS, AND THE RESIDUAL	33
	3.1 Introduction	33
	3.2 Basic Model	33
	3.3 Model I: A Standard Neoclassical Growth Model With or Without Technical Change	37
	3.4 Model II: The Introduction of the Human Capital Variable in Model I Without Technical Change	41
	3.5 Model III: A Modified Growth Model With Endogeneous Labor Component and Harrod-Neutral Technical Progress	42
	3.6 Limitations and Concluding Remarks	46

Chapter page

4. INVESTMENT IN HUMAN CAPITAL: A MICROECONOMIC APPROACH..... 50

4.1 Introduction..... 50

4.2 The Cost of Producing Human Capital..... 52

4.3 The Profitability of Investments in Human Capital Assets..... 57

4.4 Conceptual Difficulties and Limitations..... 68

4.5 Concluding Remarks..... 75

5. TRAFFIC SAFETY AS A PUBLIC INVESTMENT..... 78

5.1 Introduction..... 78

5.2 The Nature of Traffic Safety..... 79

5.3 Government Intervention..... 81

5.4 The "Price" of Traffic Safety..... 84

5.5 The Presence of Uncertainty and Moral Hazard..... 86

5.6 Social Goods and Costs-Benefits Analysis..... 90

5.7 Cost-Benefit and Criteria for Investment..... 92

5.8 Net Benefit and the Discounting Method.. 93

5.9 Criteria of Preference or Investment Decision Rules..... 94

5.10 Choice of the Discount Rate..... 99

5.11 Treatment of Risk and Uncertainty..... 110

5.12 Conclusion..... 118

Chapter page

6. A HUMAN CAPITAL APPROACH TO VALUE HUMAN BEINGS: A CASE STUDY IN THE AUTOMOBILE ACCIDENTS 123

6.1 Introduction..... 123

6.2 Development of a Conceptual Measure of Human Capital..... 126

6.3 Measurement of Economic Losses..... 131

6.4 Concluding Remarks and Limitations..... 163

7. CONCLUSION..... 169

BIBLIOGRAPHY..... 181

LIST OF FIGURES

Figure		page
1.	The Optimal Rate of Production of Human Capital.....	59
2.	The Maximum Present Value of an Investment in Human Capital.....	61
3.	Net Earnings Time Profile of Human Capital Formation.....	66
4.	Time Profiles of Human Capital Formation.....	67
5.	Value of Housewives' Production According to the Number of Responsability Units.....	151

LIST OF TABLES

Table		page
1.	Earnings of Wage Earners by Age Group and Sex	134
2.	The Determination of the Social Rate of Discount: An Exemple	144
3.	Data for Males Used in the Computation of the Present Values of Gross Earnings by Age Group	147
4.	Data for Females Used in the Computation of the Present Values of Gross Earnings By Age Group	148
5.	Average Number of Women's Household Responsability Units by Age Group	152
6.	Present Values of Gross Future Earnings, Canada 1961, by Age Group and Sex, at 8 per cent Discount Rate	153
7.	Gross Future Earnings Losses from Traffic Accident Deaths, Canada 1961, by Age Group and Sex, at 8 per cent Discount Rate	155
8.	Production Losses Expected from Traffic Accident Injuries, Canada 1961, by Age Group and Sex	157
9.	Total Economic Losses from Traffic Accidents and Per Cent of Lost out of Total Losses, Canada 1961	162

Chapter 1. INTRODUCTION

The bulk of classical and neoclassical economic analysis has emphasized the division of the factors of production into three categories: land, labor and capital. Land and labor were understood as the only 'original' factors of production and capital goods as the products of only these factors. While labor was treated as a primary factor, capital was identified with the physical capital stock. Traditional economic theory accepted the classical notion of capital as applicable only to that portion of the man-made stock of tangible wealth which was utilized directly in future production. Capital viewed as a factor of production, consisted of produced intermediate goods that were used in producing other goods. As a factor of production, labor was assumed to be a rather homogeneous input free, in any case, from any capital component.

The traditional concept of capital is too narrow. If a broader perspective is taken, the intangible producer 'goods' in the form of "the acquired and useful abilities" and knowledge of human beings are also capital. If human capital is defined in terms of the individual's productive skills, talents and knowledge, it provides then an appropriate and useful method to explain and measure individual's contribution to production.

In the past, economists have frequently disregarded the acquired embodied skills in man, and more specifically, in workers. Trying to understand the reasons why economists have been reluctant in considering the human capital concept as an analytical tool to explain the acquisition and the economic importance of these skills will be the concern of Chapter 2. Perhaps the principal reason is that human capital assets cannot be bought and sold in the market place. If expenditures on physical capital stock have been distinguished from other expenditures from a national accounting point of view, expenditures on human capital have generally not be isolated because of the neglect at the theoretical level.[1] Certainly, the human assets should merit as much concern as physical assets in that they also contribute to the growth of national product. Economic analysis should be aware of the important role that human capital plays in the economy and of the usefulness of the concept in explaining economic growth, investment, both public and private, as well as income distribution.

Chapter 3 will stress the importance of human capital as a factor of production. Discussion will center around

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1. This neglect, while common, was not complete. See footnote 1, page 10.

the technical relationships between input and output where human capital 'input' is considered as important as physical capital in the explanation of output growth. Human capital is introduced in an aggregate production function by assuming that the growth of labor may be both endogeneous and exogeneous. The quantitative and qualitative dimensions of labor are certainly worthwhile candidates for the explanation of the large residual in the measurement of economic growth.

From the points of view of the individual and of society as a whole, human capital, especially the 'knowledge and skill' of workers, is equivalent to a large extent to physical capital goods. Drawing an analogy between physical capital and human capital, A. Smith commented:

> "When any expensive machine is erected, the extraordinary work to be performed by it before it worn out, it must be expected, will replace the capital laid out upon it, with at least the ordinary profits. A man educated at the expense of much labor and time to any of those employments which require extraordinary dexterity and skill, may be compared to one of those expensive machines. The work which he learns to perform, it must be expected, over and above the usual wages of common labor, will replace to him the whole expense of his education, with at least the ordinary profits of an equally valuable capital. It must do this, too, in a reasonable time, regard being had to the very uncertain duration of human life, in the same manner as to the more certain duration of the machine." 1

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1. Smith, A., The Wealth of Nations, Homewood, Illinois: Richard D. Irwin, Inc., 1963.

Viewed as both consumer and producer agents, human beings acquired both consumer and producer abilities. Producers abilities are the result of investment and sources of income-streams. Investments in both human and physical capital necessitate the sacrifice of goods and/or services that might otherwise have been produced. And both will yield future returns. The essential capital formation features are the same. The main function is to raise the productivity of both capital assets. The acquisition and maintenance of human capital in the form of "inherited and acquired abilities" are analogeous to those of physical capital. Both are subject to depreciation and obsolescence. Thus, if the link between output and tangible capital has been obvious, there is no reason to believe that the link between output and human capital is not important. The role of human capital in production and human capital formation are examined in Chapter 4. Following the capitalization procedure,[1] our discussion presents human capital formation as a useful analytical concept in attempting to understand labor productivity, and therefore earnings

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1. Capitalization is understood as being the capitalized-earnings approach. It consists of finding the present capital value of a future earning stream.

capacities.[1] The analogies between physical capital and human capital can however be carried only so far. Human capital cannot be analysed exactly in the same way as physical capital and the differences should be kept in mind.

If the preceeding chapter is concerned with the increase of labor's productivity by increasing its productive capacities, individuals' decisions to invest in their human capital face many market imperfections. Chapter 5 deals with some of these imperfections. It identifies traffic safety as a socially desirable good, and stress the importance of government intervention in the area of social goods. If safety is a social good, why should society invest in a such good that could lengthen labor's productive life or preserve the stock of human capital? Why should the decision not be left to the individual? Several answers can be given to this fundamental problem. Among them, the existence of public goods and externalities are investigated.

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1. Human capital is also used to explain the income distribution problem. This problem will not be discussed in this study. Interested readers are referred to Mincer, J., "The Distribution of Labor Income: A Survey with Special Reference to the Human Capital Approach", Journal of Economic Literature, 8 (March, 1970), pp. 1-26; Chiswick, B.R., "An Interregional Analysis of Schooling and the Skewness of Income", Lee Hansen (ed.), Education, Income and Human Capital, National Bureau of Economic Research, 1970, pp. 157-191; also Hansen, W.L., B.A. Weisbrod and W.J. Scanlon, "Schooling and Earnings of Low Achievers", American Economic Review, 60 (June, 1970), pp. 409-418.

Investments are of fundamental importance in the production and preservation of human capital.[1] As for private investment in physical capital, public investment is faced with the problem of efficient allocation of resources. Trying to find social investment criteria that will promote efficient decision making in the traffic safety area faces many difficulties related to the appropriate rate of discount and to the problem of handling risk and uncertainty as well as the evaluation of human life saved from the supply and/or the improvement of traffic safety.

Finally, we introduce in Chapter 6, a conceptual framework for measuring and determining the economic losses resulting from automobile traffic accident fatalities. Using this framework we then estimate the total economic losses in Canada as a consequence of death and injury due to automobile accidents. An explicit distinction should be made, however, between human capital value and the value of human life. The use of the gross capitalization formula which indicates only the present value of man's future earnings says nothing about man's economic worth

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1. Expenditures of all governments in Canada (1961) on education and health represented 4.5 per cent and 2.5 per cent of the gross national product respectively. Their average annual rate of growth (1961-1967) was 15.7 per cent and 14.1 per cent respectively. See Canada, Economic Council, Design for Decision Making: An Application to Human Resources Policies, 8th Annual Review, September, 1971, Ottawa: Queen's Printer, 1971, p. 7.

as a human being. The calculation of individuals' human capital should be supplemented by some estimation, however crude, of affective and psychic values. Any social investment in traffic safety that saves life or reduces the losses from automobile accident deaths and injuries can therefore, and in principle, be subjected to economic analysis, however crude.

Chapter 2. WHAT HUMAN CAPITAL IS

2.1 Introduction

The symmetry between the concepts of physical or tangible conventional capital and human capital is to-day widely accepted by economists. As it is true for physical capital, the acquisition and maintenance of human capital involve real economic costs as well as promise of future returns over time. From a theoretical point of view, both concepts may be valued by "discounting expected future income from them, and rates of return on both types of investment can be computed".[1] This view necessarily involves assigning a capital value to human beings so as to find a way to measure both human capital stock and human capital formation. But many economists have been "reluctant to consider human beings as an input within the 'capital' framework".[2] This can generally be explained by the institutional fact that our modern societies expressly prohibit markets in human capital.[3]

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1. Goode, R.B., "Adding to the Stock of Physical and Human Capital", American Economic Review, 59 (May, 1959), p. 148.

2. Kiker, B.F., Human Capital in Retrospect, Columbia, S.C.: College of Business Administration, University of South Carolina, 1968, p. 8.

3. While tangible capital goods are typically bought and sold, only the services of labor are marketable.

In this chapter we shall examine first, the classical views and reluctance toward the concept of human capital. There exists a general agreement among the classical economists as to include man's acquired abilities and skills in their definition of capital. While recognizing the importance of human capital formation which increases man's productivity, they generally neither attempted a valuation of these skills and abilities nor employed the concept of human capital for any specific purpose. Second, the main controversies about the nature of capital will be briefly surveyed. Third, the concept of physical capital vs. the concept of human capital as found in the present framework of most national accounts system will be discussed. Some economists have proposed ways in which human capital and other intangibles[1] be included in a suggested alternative system of economic accounts. Finally, some of the general uses of the concept of human capital are stated. Many present-day economists utilized the concept as a powerful tool capable of explaining some important and previously unexplained economic phenomena.

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1. Intangible capital assets are identified as having no material substance and not representing anything material. They result from human capital formation and other resources. Ways to quantified them are not satisfactory. Although human capital assets (e.g. skills) can possibly be estimated, their values are not directly determined by the market.

2.2 Classical Views and Reluctance

Since the days of Sir William Petty, many economists have included man in the concept of fixed capital, because like physical capital human capital is subject to costs and promises future returns. Among these economists, some of those belongning to the Classical School deserve our special attention.[1] Among other things, they contributed to the development of economic theory by including "human beings or their acquired abilities and skills, as a component of capital — generally, fixed capital".[2] Most of them believed that human beings should be included in the concept of capital for three reasons: 1) the cost of rearing and educating human beings is a real cost; 2) the product of their labor adds to national wealth; 3) an expenditure on a human being which increases his productivity will, ceteris paribus, increase national wealth.[3]

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1. B.F. Kiker has done an exhaustive study of past and recent work involving the concept of human capital. He investigated the economic literature to determine who treated man as capital and the procedures for valuing human beings in monetary terms. According to Kiker, the notion of human capital was held by many economists, statisticians, and actuaries who have set forth, before the classical economists, procedures for estimating the human capital value. See Kiker, B.F., op. cit., and Kiker, B.F., The Concept of Human Capital, loc. cit., 1966. This study has been recently completed by the survey of Mincer, J., "The Distribution of Labor Income: A Survey with Special Reference to the Human Capital Approach", Journal of Economic Literature, 8 (March, 1970), pp. 1-26.

2. Kiker, B.F., Human Capital in Retrospect, loc. cit., p. 25.

3. Ibid., p.25.

Adam Smith included in a country's stock of fixed capital the "acquired and useful abilities of all the inhabitants or members of the society".[1] Although he did not consider the human being per se as capital, Smith is probably the first economist to use an all-inclusive concept of capital. In his logical framework he suggested that these skills and abilities, now often called human capital, represent real economic costs on the ground that:

> "The acquisition of such talents, by the maintenance of the acquirer during his education, study or apprenticeship, always costs a real expense, which is a capital fixed and realized as it were, in his person. Those talents as they make a part of his fortune, so do they likewise of that of the society to which he belongs. The improved dexterity of a workman may be considered in the same light as a machine or instrument of trade which facilitates and abridges labour, on which, though it costs a certain expense, repays that expense with a profit". 2

The capital embodied in people is, therefore, considered as part of fixed physical capital. If capital stands for produced means of production, it follows that the 'living capital' is produced by using up ressources and makes production physically possible.

J.R. McCulloch, in his Principle of Political Economy, agreed with Smith that the capital embodied in man should be considered as part of a country's stock of fixed capital.

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1. Smith, A., The Wealth of Nations, loc. cit., p. 214. Fixed capital includes such things as land improvement and equipment. Included also are the acquired and useful abilities.

2. Ibid., p. 214.

However, more comprehensively, he extended the interpretation of capital by considering human beings per se as a component of fixed physical capital. Thus, this led him to interpret investment in man and the resulting expenditures and maintenance as capital formation. Like any other physical investments, investments in human beings should yield expected future income.[1]

Among a few other economists who have looked upon human beings as capital,[2] Irving Fisher presented the logical basis of an all-inclusive concept of capital, which clearly includes man as capital. This concept treats all sources of income as a form of capital. He recognized the difference between stocks and flows in his definition of capital considering it as a stock of material goods and human skills that yields a flow of services over time. "The logical outcome of this view, as Mark Blaug stated it, is that capital is the only factor of production, that all distributive income consists of interest, wages being merely the interest payments on the stock of human capital and that the national income consists entirely of consumption expenditures".[3]

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1. Kiker, B.F., op. cit., pp. 30-31.

2. Along with A. Smith and J.R. McCulloch, J.B. Say, Nassau Senior, F. List, H.D. McLeod, J.H. von Thünen, L. Walras, H. Sidgwick and A. Marshall have treated human beings as a component of fixed capital. See Kiker, B.F., op. cit., pp. 25-53. One may also add Malthus, Ricardo and J.S. Mill: see Blaug, M., Economic Theory in Retrospect, (rev. ed.) Homewood, Ill.: Richard D. Irwin, Inc., 1968, pp. 78-79; 182-183.

3. Ibid., p. 586.

A general agreement about the inclusion within the concept of capital of the capital embodied in man exists among economists. Although these economists have defined man as capital, any of them has "neither attempted an evaluation of this capital nor set forth procedures for making such a calculation".[1] In view of Alfred Marshall's great prestige this attitude might be understandable. In fact, Marshall recognized that human beings are incontestably capital "from the abstract and mathematical point of view" but disregarded the entire notion on the basis that it would be out of touch with the market place to treat man as capital in practical studies.[2]

Why has the main stream of modern economics been so slow in acknowledging the role of human capital and undertaking any systematic analysis of it? Several reasons may be stated why this occured.

Many economists have been led away from considering human capital because the classical breakdown in land, labor, and physical capital was convenient. Labor was treated as a

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1. Kiker,B.F., op. cit., p. 28.

2. Marshall, A., Principles of Economics, (8th ed.), London: Macmillan Co., 1949, Appendix E, pp. 649-650. J.H. von Thünen has argued, however, that many social injustices would be avoided, especially during wars, if the capital embodied in man were included in the concept of capital. He said, for example, that a hundred men might be sacrificed in battle in order to save one canon with capital value 20 times less than the capital value of the men. Physical capital is, therefore, treated as much more valuable than human beings, situation which, according to him, is very unfortunate. See Kiker, B.F., op. cit., pp. 39-43.

homogoneous commodity, free from any capital component.

Joan Robinson has argued, however, that there does not exist a clear cut distinction "between income from work and income from property".[1] She added that from the individual's point of view, acquiring future earning power by investing in his training may be an alternative to investing in his physical capital, but it is different in an important respect: this investment is not marketable "so that the present capital value of future personnel earning power has a metaphorical, not an actual financial meaning".[2] Fron the point of view of the economy as a whole, Joan Robinson notes, however, that the similarity is more important than the difference. The stock of human capital has to be maintained or/and increased just as physical capital.[3]

The Classical School, by differentiating the notion of labor as a unique original factor of production, distinct from natural resources and from capital goods, has contributed to the neglect of human capital. The treatment of labor as an original factor and the identification of capital with the physical stock of capital equipment "has fostered the retention

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1. Robinson, J., The Accumulation of Capital, (2nd ed.), New York: St. Martin's Press, Inc., 1966, p. 11.

2. Ibid., pp. 11-12.

3. Ibid., p. 12.

of the classical notion of labor as a capacity to do manual work requiring little knowledge and capacity".[1] If the central problem was how output should be divided among the three factors of production, human capital differentials among individuals were ignored since labor was being treated as homogeneous. According to T.W. Schultz, this notion of labor is wrong. He argued that labor homogeneity is meaningless and that labor as such does not measure the quantity of an economic factor as to determine its economic importance. The knowledge and skill of labor have an economic value which is in great part the product of human investment. Thus, labor must be treated as the produced mean of production, as the product of investment like physical capital. However, the main difference with physical capital is that labor is necessarily present when its productive services are used in the processes of production.[2]

Second, the neglected notion of human capital by economists has arisen from the traditional restriction on the concept of capital. Despite the fact that I. Fisher has presented an all-inclusive concept of capital, the prestige of Alfred Marshall was so great that economists confined themselves to developing and using the concept of capital

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1. Schultz, T.W., "Investment in Human Capital", American Economic Review, 51 (March, 1961), p. 3.

2. Johnson, Harry G., "The Political Economy of Opulence", The Canadian Journal of Economics and Political Science, 26 (November, 1960), p. 562.

including only assets that are commonly bought and sold in the market place. Our social institutions have been shaped to keep man free and not marketable. Marshall made it clear that "we are seeking a definition (of capital) that will keep realistic economics in touch with the market place..."[1] excluding, then, all capital that becomes an integral part of man.

This notion of 'market place' could have been given a much better and broader interpretation. Wages and salaries are determined in the market place; they represent income streams and, like the income streams from physical property, "they may be discounted with appropriate capital values imputed to them".[2] Furthermore, human capital formations, like physical capital formations, are ways of establishing additional income streams.[3] Before we proceed to the discussion of the human capital concept in the National Accounts framework it would be appropriate to say a few words on the pure theory of capital.

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1. Marshall, A., op. cit., p. 650.

2. Kiker, B.F., The Concept of Human Capital, loc. cit., p. 3.

3. Other reasons why economists have been reluctant to undertake a systematic analysis of human capital are the difficulty of measurement arising from the investment-consumption dichotomy and the problem of the intangible capital assets. These problems will be examined in Chapter 4.

2.3 A Note on the Pure Theory of Capital and Interest

Capital theory "is the economics of time". Time "explains if, and why, a lasting instrument of production can be expected to contribute more to the value of output during its lifetime than it costs to produce or acquire".[1]

Conflicting views on the nature of capital, the existence of interest, and the determination of investment levels have brought capital theory in a number of controversies that centered around the complex problem of choice among dated productive and consumptive commodities.[2] Traditionnally, capital theory has examined the allocation of resources between different uses at either the stationary state or at one point in time and, the period of production, that is, the delay between the application of inputs and the emergence of the resulting output. Among the economists who are especially remembered for their contributions to the theory of capital and interest are Eugen Böhm-Bawerk, Knut Wicksell and Irving Fisher.

The key to the problem of capital is, in Böhm-Bawerk's view, the reason why a produced mean of production "permits

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1. Dorfman, R., "An Economic Interpretation of Optimal Control Theory", American Economic Review, 59 (December, 1969), p. 817.

2. Hirshleifer, J., Investment, Interest and Capital, Englewood Cliffs, N.J.: Prentice-Hall Inc., 1970, pp. 158-160.

adoption of more productive but also more time-consuming roundabout methods of production".[1] In his view, capital is regarded as a good-in-process which simply yields final goods after a period of waiting. The longer is the roundabout process of production, the longer will be the interval of waiting time between the application of inputs and the emergence of the final goods. From these observations, Böhm-Bawerk provided a stationary-state solution to measure the value of capital, in which solution the producible factors of production are periodically extinguished and replaced.[2]

He introduced the concept of interest to value capital by advancing three separate reasons that placed higher value on present goods over future goods. The first two are of psychological nature and cause the value of future goods to be discounted to the present. The third reason derives from the technical superiority of present goods over future goods. Both the optimum length of the production period and the rate of interest are determined by the interaction between the psychological reasons and the superiority of the roundabout method of production.[3]

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1. Blaug, M., op. cit., p. 501.

2. Kuenne, R.E., The Theory of General Equilibrium, Princeton, N.J.: Princeton University Press, 1963, pp. 237-240.

3. Blaug, M., op. cit., pp. 507-509.

Böhm-Bawerk has been critisized for assuming independance of the technical superiority of present over future goods from the rate of interest. Fisher claims that the premium individuals are willing to pay for present goods over future goods is due to their time preference ("human impatience").[1] Along with Wicksell and other followers of Böhm-Bawerk, Fisher objected to the technical superiority of present goods over future goods. He chooses instead to ground the technical basis for the existence of interest "in the greater productivity of roundabout processes or innovation";[2] this productivity should affect the relative abundance of present and future goods. Fisher sees, therefore, the rate of interest as being determined by "human impatience" (analogous to Böhm-Bawerk's first two conditions) which interacts with "opportunity" for investment.[3]

Wicksell's theory of capital and interest is related to the capital structure. It reflects a productive process in which the number of inputs invested in capital goods at a point of time ("height") results after a period of production or investment in a final output which is greater the longer the period of production allowed.[4] The length of time over which such land

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1. For a more complete investigation of the controversies in capital theory, see Kuenne, R.E., op. cit., pp. 196-287.

2. Ibid., p. 279.

3. Blaug, M., op. cit., p. 530. For a demonstration of the way in which these factors interact for both individual and market equilibrium, see Ibid., pp. 531-540.

4. Swan, T.W., "Economic Growth and Capital Accumulation", Economic Record, 32 (November, 1956), p. 352.

and labor inputs must remain invested before their services are extinguished is called the "width" of inputs invested in capital goods. The economic value of this capital structure is given by the present value of the outputs. Like Fisher, he rejected the technical superiority of present goods and rather grounded the technical basis for the existence of interest in the greater productivity of roundabout production processes and he thought of interest as being a percentage rate of growth of the value of the outputs. He was interested in the period of production as being nothing but "a mathematical concept, without direct physical or psychic significance", but which "should, nevertheless be retained as a concise general principle, reflecting the essence of productive capital".[1]

The dependance of the period of production or investment on the rate of interest is thus considered as the "nucleus" of the Austrian capital theory. The concept of capital is reduced to the relative time interval that must elapse between the first investment in primary factors and the emergence of output for which land and labor were responsible. From this conception of capital, a number of conflicting disputes centered around the independance of time preference assumption and the technical superiority of present goods over future goods. This

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1. Wicksell, K., Lectures on Political Economy, London: Routledge & Kegan, Paul, Ltd., 1949, p. 184.

independance seemed to be a complicated proposition to establish and Kuenne concluded on the ambiguities of Böhm-Bawerk's third reason for interest that "it seems much more fruitfull to employ the productivity of roundabout processes exclusively as the productive component of the theory of interest".[1]

The chief problem of all capital accumulation and growth is that of determining the amount of resources that should be allocated to production of both physical and human capital to be used for producing consumption goods in the future. Since capital theory was traditionnally confined to stationary equilibrium where "further capital accumulation is not worthwhile", the mode of analysis "confined to a distant position is poorly suited to the understanding of accumulation and growth, but no other technique seemed available for most of the history of capital theory".[2] Capital theory is now perceived as a problem of optimal control theory. Much progress has been made since in growth theory and a number of "important practical and theoretical issues that previously could not even be formulated"[3] have been resolved.

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1. Kuenne, R.E., op. cit., p. 286.

2. Dorfman, R., op. cit., p. 817.

3. Ibid., p. 817.

The concern in this thesis being the finding of a criterion for static decision-making in traffic safety, our approach to capital will mainly be Fisherian.

2.4 Treatment of Human Capital Assets In National Accounts

Capital is generally defined as "all goods produced for use in future productive processes".[1] These goods include residential buildings, non-residential buildings and other construction, machinery and equipment, producer's stock resources, and intermediate and finished goods. Capital may be either gross or net. Net capital is measured from the gross figure after allowance "for capital consumption valued at curent prices — depreciation allowance, obsolescence, and accidental damage to fixed capital".[2] On a conceptual basis, net capital formation represents the addition to the stock of fixed physical capital in the form of reproducible instruments of production for future output.[3]

Without going any further into the long controversial definition of physical capital and examining in detail the

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1. United Nations, Concepts and Definitions of Capital Formation, Studies in Methods, Series F., No 3, New York: United Nations, 1953, p. 7.

2. Canada, Dominion Bureau of Statistics, Fixed Capital Flow and Stocks Manufacturing Canada 1926-1960, (Cat. No. 13-522), Ottawa: Queen's Printer, 1967, pp. 8-14.

3. Canada, Dominion Bureau of Statistics, National Accounts Income and Expenditure 1926-1956, (Cat. No. 13-502), Ottawa: Queen's Printer, 1962, Part II.

differences in the usage of the term[1] one must be aware of the fact that for purpose of measurement, there is a recognized omission or underestimation of net capital formation and accumulated stock because capital formation is identified with the net increase of fixed physical capital and working capital.

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1. Trygve Haavelmo states that it is "very difficult to define capital as a physical object without referring to its economic functions". Indeed one is faced with the problem of heterogeneity while choosing an a priori statistical criterion to ascertain capital goods from the point of view of their economic functions, or with the controversial discussion on how to measure the 'amount' of capital by reference to its economic functions. Haavelmo, T.A., A Study in the Theory of Investment, Chicago: University of Chicago Press, 1960, p. 43. This problem had recently lead C.E. Ferguson and Joan Robinson to a discussion on this controversial issue. The main area of discord between them arises on the extension by analogy of the neoclassical microeconomic theory of input pricing to the macroeconomic aggregates. We are not going to review the areas of confusion of this "tedious and unnecessary" debate but only mention that whether or not this (analogy with the corresonding microeconomic concepts) is "useful is an empirical question" to which Ferguson "believe an empirical answer can be given". Perhaps it would be better to say, as Ferguson suggested, "that the aggregates analogy provide working hypotheses for econometricians". See Ferguson, C.E., "Capital Theory Up to Date: A Comment on Mrs. Robinson's Article", Canadian Journal of Economics,4 (May, 1971), pp. 250-254. For the readers who might be interested on what the controversial issues are, see: Ferguson, C.E., The Neoclassical Theory of Production and Distribution, Cambridge, Mass.: Harvard University Press, 1969; Robinson, J., "Capital Theory Up to Date: A Reply", Canadian Journal of Economics, 4 (May, 1971), pp. 254-256. See also the debate between Franklin M. Fisher and Joan Robinson on whether or not the aggragate production functions are satisfactory in explaining factor shares. Fisher, F.M., "The Existence of Aggregate Production Functions", Econometrica, 37 (October, 1969), pp. 553-577, and Robinson, J., "The Existence of Aggregate Production Functions: Comment", and the "Reply" by F.M. Fisher, Econometrica, 39 (March, 1971), p. 405.

The present framework of our existing national accounts is, in fact, designed to the measurement of economic activity in the market including imputed measurement for a few selected nonmarket activities that have a close relation to related market activities. Basically used by economists and statisticians to analyse cyclical changes and growth in total activity, the concept of Gross National Product provided the opportunity to include more statistical informations about the operation and functionning of the economy and is for most people, including economists, closely related to economic welfare.

This conceptual framework of the accounts contain itself many sources of dissatisfactions. The current dissatisfactions, well stated by Thomas Juster,[1] are related to a number of specific areas: 1) the treatment of nonmarket activities for which income-producing activities are excluded from the accounts (e.g., the actual system of accounts does not consider the housewive's activities as output);[2] 2) the distribution of output between consumption and investment: the way in which

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1. Juster, T.F., "On the Measurement of Economic and Social Performance", Economics — A Half Century of Research 1920-1970, (50th Annual Report, September, 1970), New York: National Bureau of Economic Research, 1970, pp. 8-24.

2. The nonmarket production of housewives' services does not justify, however, an assumption that their services are valueless. In valuating man's net contribution to output as a component of human capital, Burton A. Weisbrod used the replacement cost method to estimate the housewives' production. Weisbrod, B.A., Economics of Public Health, Philadelphia, Penn.: University of Pennsylvania Press, 1961, p. 49, pp. 114-119.

these two elements are classified in the accounts does not measure total investment since net capital formation represents only the addition to the stock of fixed physical capital in the form of business assets and residential constructions. In particular, investment in human capital which is a growing form of capital outlay and probably the largest component of total investment in the economy still not to be recognized in the system of accounts as investment; 3) finally, the inadequate measure of social and economic welfare has become apparent. Gross National Product and welfare measures are at variance with each other. "If a man's wife is killed in an automobile accident and he is thus forced to hire a housekeeper to care of his children, the GNP will rise because housekeeper's services are counted and housewive's services are not — and the stock of human capital is not reduced because it was not counted to begin with".[1] The capital lost in destruction of lives does not, therefore, explicitely enter into the system of accounts and is still ignored.

In a recent study, Nancy and Richard Ruggles suggested a number of modifications to the actual United States and United Nations systems of accounts.[2] They proposed an alternative

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1. Juster, T.F., op. cit., p. 12.

2. Ruggles, N., and R. Ruggles, The Design of Economic Accounts, New York: National Bureau of Economic Research, 1970, p. 184.

framework of accounts in which GNP, consumption expenditures, capital formation, personal income and disposable income would be disaggregated and deconsolidated into their component parts. These components "must provide identifiable economic variables which are important for economic analysis. The success of economic research depends upon the development of operational concepts capable of statistical measurement".[1] This development seems worthwhile since the prime objective of a system of accounts is to provide a comprehensive framework suitable for analysing (and measuring) the operation of social and economic performance.

The alternative framework proposed states that "economic and social output can be thought of as a flow of satisfactions or utilities generated by combining the services of various types of capital assets".[2] Well stated by Juster as being made of 1) tangible capital assets (equipment and structures); 2) intangible capital assets (e.g., knowledge); 3) human capital assets (skills and talents); 4) physical environmental assets and 5) sociopolitical environmental assets, this break down of

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1. Ibid., p. 4.

2. Juster, T.F., op. cit., p. 14.

capital could, in principle, provide a useful and possible framework of accounts. Although the empirical implementation is another matter,[1] tangible assets should comprise not only business assets but both consumer and government assets. Intangible capital assets resulting "from the application of human capital and other resources to research and development problems"[2] are considered part of capital formation only to the extend that they contribute to the addition to the stock of physical capital assets. Not being carried over the concept of physical capital and, therefore, not being explicitly stated in the present system of accounts, one must recognize that intangible capital assets along with human capital does constitute current productive economic activity. Factors such as education, training, health constitute valuable assets and should be classified in our national accounts as capital formation.[3]

Any attempt to broaden the definition of capital and investment thus lead to the inclusion in a country's stock of fixed capital of a number of additional categories of current expenditures on "health services, human migration, accident prevention and education, both formal and on the job"[4]

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1. Beyond the recent study of Nancy and Richard Ruggles, other research projects directed by both J. Kendrick and R. Eisner at the National Bureau of Economic Research are currently engaged as to provide empirical estimates of such capital assets.

2. Juster, T.F., op. cit., p. 15.

3. Ruggles, N., and R. Ruggles, op. cit., p. 42.

4. Kiker, B.F., The Concept of Human Capital, loc. cit., p. 1.

which improve technology and contribute to future production. This is called human capital formation. These acquired embodied features in human beings are often called human capital assets.

2.5 General Uses

As seen in the previous sections, the concept of human capital is by no means new. By treating human beings as physical capital, many economists have devoted a great deal of effort to the development and quantification of an all-inclusive concept of capital as applied to man. Although some economists have been reluctant to value human beings as physical capital based on somewhat irrational fear that to do so is morally wrong, it may be contended, however, that the concept of human capital may be considered to be a useful and powerful tool capable of explaining some important and previously unexplained phenomena.

The concept of human capital is applied through the concept of investment in the formation of human capital. Despite the difficulty of a definition and an exact measurement of human capital formation, still the important question is to look at the many insights that can be gained from examining some activities that could improve human beings. Expenditures on such activities may contribute to the value of our human resources, thus preserving and enhancing these values just as in the case for nonhuman capital.

As a practical matter, the human capital approach to such activities provides capitalized values which are substitutes for market valuations. In this way, human capital investment programs that improved human beings can be economically determined.

These estimates of the capitalized values of human capital are potentially useful for different purposes.[1] The human capital approach has been generally advocated for the following uses: 1) as an index of welfare;[2] 2) the study of economic growth;[3] 3) decision-criterion for human migration;[4] and

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1. Weisbrod states that rational population and immigration policies assessment of public health, highway construction and flood-control, inter-regional migration, education and vocational rehabilitation are programs among others in which human capital values would be of a great aid in developing policies. See Weisbrod, B.A., "The Valuation of Human Capital", Journal of Political Economy, 69 (October, 1961), pp. 425-426.

2. Weisbrod, B.A., "An Expected-Income Measure of Economic Welfare", Journal of Political Economy, 70 (August, 1962), pp. 355-367. Weisbrod attempted to use per capita human capital values as desirable measure of a welfare index instead of using per capita income.

3. Kuznets, S., "Long Term Changes in National Income of the United States Since 1870", S. Kuznets (ed.), Income and Wealth of the United States, Cambridge, Mass.: Bowers & Bowers, Ltd., 1952, and Kuznets, S., Capital in the American Economy: Its Formation and Financing, New York: National Bureau of Economic Research, 1961, p. 390.

4. Kuznets, S., National Income: A Summary of Findings, New York: National Bureau of Economic Research, 1946, pp. 47-49, and Sjaastad, L.A., "The Costs and Returns of Human Migration", Journal of Political Economy, Supplement, 70 (October, 1962), pp. 80-98.

4) population policies;[1] 5) extent of information in the labor market[2] and 6) educational and on-the-job training policies;[3] 7) investment decision that reduces losses of human capital.[4] This list is by no mean complete. It points out, however, the importance of creating and preserving the human capital values through benefits gained by individuals

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1. Marshall, A., op. cit., p. 469.

2. Stigler, G.J., "Information in the Labor Market", Journal of Political Economy, Supplement, 70 (October, 1962), pp. 94-105, and Stigler, G.J., "The Economics of Information", Journal of Political Economy, 69 (June, 1961.

3. Several economists have studied different portions of these problems. Becker, G.S., "Investment in Human Capital: A Theoretical Analysis", Journal of Political Economy, Supplement, 70 (October, 1962), pp. 9-49; Becker,G.S., "Underinvestment in Education", American Economic Review, 50 (May, 1960) pp. 346-354; Becker, G.S., Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education, New York: National Bureau of Economic Research, 1964; Schultz, T.W., "Investment in Human Capital", loc. cit., pp. 1-17; Schultz, T.W., The Economic Value of Education, New York: Oxford University Press, 1963; Schultz, T.W., Investment in Human Capital, New York: Macmillan Co., 1971; Weisbrod, B.A., "Education and the Investment in Human Capital", Journal of Political Economy, Supplement, 70 (October, 1962), pp. 106-123; Mincer, J., "On-The-Job Training: Costs, Returns and some Implications". Journal of Political Economy, Supplement, 70 (October, 1962), pp. 50-79; Welch, F., "Education in Production" Journal of Political Economy, 78 (January/February, 1970), pp. 35-59.

4. Weisbrod, B.A., The Economics of Public Health, loc. cit.; Fein, R., Economics of Mental Illness, New York: Basic Books, Inc., 1958; Mushkin, S.J., "Health as an Investment", Journal of Political Economy, Supplement, 70 (October, 1962), pp. 129-157; Reynolds, D.J., "The Cost of Road Accidents", Journal of the Royal Statistical Society, Series A, 119 (1956), pp. 393-400; Thedie, J., and C. Abraham, "Economic Aspect of Road Accidents", Traffic Engineering and Control, 2 (February, 1961), pp. 589-595.

or society and that human capital is an important conceptual and measurable tool for the analysis of economic growth and investment decision making.

2.6 Conclusion

In this chapter we have tried to present the concept of human capital as a part of an all-inclusive concept of capital. It is presently omitted from the system of national accounts. Many economists have neglected to treat human beings as form of capital mainly because labor was thought as being a unique original factor of production without any capital component, and because of the traditional restriction of the concept of capital to physical items promising future returns that are bought and sold in the market-place. They conceptually recognized that the stock of human capital has to be maintained and increased without doing, however, any empirical estimation and implementation in policies.

Fortunately, the situation has improved. Some economists have understood that the concept of human capital is a useful and powerful tool capable of explaming a number of economic phenomena. Estimates of human capital values are potentially useful for human capital formation: these capitalized values of human capital are especially of a great help in taking decisions that improved and preserved human beings.

The concept of human capital and its measurement still face some difficulties. A great need still exists in National Accounts to broaden the definition of capital and investment as to include human capital formation. Recent studies suggested a more comprehensive framework of national accounts in which tangible capital assets intangible capital assets and human capital assets contribute together to current productive activities. These various types of capital assets could lead, in principle, to a more comprehensive analytical and empirical analysis of the whole economic system.

Although the concept of human capital was considered by the Classical School, human capital has not played an important role in the development of economic thought. Only labor, treated as an homogeous input, land and physical capital could lead to an increase in output. In these recent years, however, emphasis has been put on the problem of economic growth and economists have considered that human capital (in the form of skills, knowledge and talents) could prove to be a major contributor to economic growth.

Chapter 3. HUMAN CAPITAL, AGGREGATE PRODUCTION FUNCTIONS, AND THE RESIDUAL

3.1 Introduction

Taking for granted that tangible and intangible capital assets are responsible for the streams of production we will try to understand the way in which physical capital and human capital can be combined to reach, at the aggregate level, a desired level of output. Since physical capital and labor-employment, together with technical changes, have generally fallen short of explaining the total growth of national output, many economists have directed their attention and research to the human capital factor which could help in explaining the growth of aggregate output. It is now widely accepted that 'skill and knowledge' embodied in labor contribute to a large extent to the explanation of economic growth. We shall therefore introduce and examine the role of human capital in aggregate production functions.

3.2 Basic Model

A major problem of the theory of economic growth was the appearance of a relatively large residual in the measurement of output unexplained by the growth of physical capital and labor inputs. The residual was often vaguely referred

to as "technical change".[1]

A simple neoclassical production function of the type

(1) $Y = F(K,L)$

showing an output flow Y as a constant-return to scale function F in both inputs K and L (physical capital stock and labor-employment respectively) is posited. Furthermore, the function F is assumed to be concaved and "well-behave" with marginal product of capital $F_K > 0$, and marginal product of labor $F_L > 0$. Assuming that F is not an explicit function of time, that all variables in (1) are explicit functions of time, differentiating (1) with respect to time and dividing by Y we obtain

(2) $$\frac{\dot{Y}}{Y} = F_K \cdot \frac{\dot{K}}{Y} + F_L \cdot \frac{\dot{L}}{Y}$$

where the dots indicate time derivatives. Equation (2) may be written

(3) $$\frac{\dot{Y}}{Y} = F_K\left(\frac{K}{Y}\right) \cdot \frac{\dot{K}}{K} + F_L\left(\frac{L}{Y}\right) \cdot \frac{\dot{L}}{L}$$

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1. For much of the empirical contributions that have attributed the residual to technical change, see especially Schmookler, J., "The Changing Efficiency of the American Economy", Review of Economics and Statistics, 34 (August, 1952), pp. 214-231; Kendrick, J.W., Productivity Trends in the United States, New York: National Bureau of Economic Research, 1961; Abramovitz, M., "Resource and Output Trends in the United States since 1980", American Economic Review (Papers and Proceedings), 46 (May, 1956), pp. 5-23; Solow, R.M., "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, 39 (August, 1957), pp. 312-320. For discussions on the size of the residual, see Kendrick, J.W., and R. Sato, "Factor Prices, Productivity and Economic Growth", American Economic Review, 53 (December, 1963), pp. 974-1003 and Schultz, T.W., Investment in Human Capital, loc. cit., pp. 62-77.

Now defining $v = F_K \cdot \left(\frac{K}{Y}\right)$ and $w = F_L \cdot \left(\frac{L}{Y}\right)$ equation (3) becomes

$$(4) \qquad \frac{\dot{Y}}{Y} = v\frac{\dot{K}}{K} + w\frac{\dot{L}}{L}$$

where v and w are identified as the factor shares. Thus under perfect competition, $\frac{\dot{Y}}{Y}$ is the weighted average, the factor shares being the weights of the relative rates of growth of the factors inputs. Under the assumption of constant-returns to scale, Euler's theorem on linear homogeneous functions guarantees that the factor shares will exhaust the total product, that is $v + w = 1$, for all t. Much empirical research has been done to estimate how much of the observed output relative growth rate is accounted for by the relative growth rate of inputs weighted by their respective factor shares. It was observed that the right hand side of equation (4) did not add up to the observed value of $\frac{\dot{Y}}{Y}$. In other words, there was a residual that could not be explained.

Various explanation of the residual have been advanced, notably technological progress and 'quality' of inputs.[1]

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1. Empirical contributions along these lines are well-known: Denison, E.F., The Sources of Economic Growth in the United States and Alternatives Before Us, New York: Committee for Economic Development, 1962; Griliches, Z., "The Sources of Measured Productivity Growth: U.S. Agriculture 1940-60", Journal of Political Economy, 71 (August, 1963); Schultz, T.W., 68 (August, 1960), pp. 571-583.

Particularly, Griliches and Jorgenson attempted to give a full explanation of growth by the rising 'quality' of the labor force.[1] The problem of handling the stock of human capital assets, in an aggregate production function, remained however open. It is only recently that Zvi Griliches has suggested ways in which human capital embodied in workers in the form of skill and knowledge could be introduced in an aggregate production function to form a complete growth system.[2]

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1. Griliches, Z., and P.W. Jorgenson, "The Explanation of Productivity Change", Review of Economics and Statistics, 34 (July, 1967), pp. 249-283.

2. The Foregoing analysis is based on Griliches, Z., "Notes on the Role of Education in Production and Growth Accounting", and Comments on Griliches' Paper by John Conlisk, in W. Lee Hansen (ed.), Education, Income and Human Capital, New York: National Bureau of Economic Research, 1970, pp. 71-124; Solow, R.M., "A Contribution to the Theory of Economic Growth", Quarterly Journal of Economic, 70 (February, 1956), pp. 65-94; Hahn, F.R., and R.C.O. Matthews, "The Theory of Economic Growth: A Survey", The American Economic Association: Surveys of Economic Theory, Vol II, New York: St. Martin's Press, 1967, pp. 1-124; Welch, F., "Education in Production", Journal of Political Economy, 78 (January/February, 1970), pp. 35-59; Conlisk, J., "A Modified Neoclassical Growth Model with Endogenous Technical Changes", Southern Economic Journal, 34 (October, 1967), pp. 199-209; Burmeister, E., and A.R. Dobell, Mathematical Theories of Economic Growth, New York: The Macmillan Co., 1970.

3.3 Model I: The Standard Neoclassical Growth Model With or Without Technical Change

First, we specify the simplest neoclassical growth model where an homogeneous flow of gross product Y per unit of time is produced by labor and by physical capital according to the production function (1). Further assumptions are needed to complete the model.

i) The current output is assumed to be allocated between consumption and capital goods. A constant fraction sY(t) of total output flows is saved at a rate s and is added to the physical capital stock. Assume moreover that capital goods depreciate at a constant rate, say δ, which is technologically given, then, the net rate of change in the aggregate stock of capital[1] is given at every instant of time t, by the equation

$$\dot{K} = sY - \delta K \qquad K(0) = K_o > 0 \tag{5}$$

ii) The size of the labor force and its rate of growth are assumed to be exogeneously given. Thus labor grows at a constant relative rate g independently

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1. Capital stock is assumed to be "malleable", that is to say, its composition is independent of previous use or of the factor proportions in its previous use. Thus capital may be transferred instantaneously to more or less capital intensive techniques of production without any cost. There is no technical progress and there is full employment of both capital and labor at any t.

of any economic variable in the systems. It is further assumed that the supply of labor is inelastic at any moment of time t, then

(6) $\frac{\dot{L}}{L} = g \qquad L(0) = L_o > 0$

Summarizing Model I:

(1) $Y = F(K, L)$

(5) $\dot{K} = sY - \delta K$

(6) $\frac{\dot{L}}{L} = g$

Substituting the production function (1) into (5) we get

(7) $\dot{K} = sF(K, L) - \delta K$

which determine the composition of demand as between output to be consumed and output to be set aside for accumulation and maintenance. Once the growth rate of capital is known and that of labor force, the time path of future output can be computed.

To see if the time path of real capital is consistent with the rate of growth of the labor force in equilibrium, we introduce $k = K/L$, the capital stock per unit of labor. Hence we have

(8) $f(k) = F\left(\frac{K}{L}, 1\right)$

where $f(k)$ defines a <u>per capita</u> production function which is continuous for $k \geq 0$, and satisfies

(9) $f(k) > 0, \quad f'(k) > 0, \quad f''(k) < 0,$

(10) $f'(k) \rightarrow \infty$ as $k \rightarrow 0$

(11) $f'(k) \rightarrow 0$ as $k \rightarrow \infty$ [1]

Differentiating k with respect to time, the relative rate of change of k is given by

(12) $\dot{k} = \left(\frac{\dot{K}}{L}\right) = \frac{\dot{K}}{L} - \left(\frac{K}{L}\right)\frac{\dot{L}}{L}$

and substituting from (6), we find

(13) $\dot{k} = \frac{\dot{K}}{L} - gk$

(14) $\dot{k} = sf(k) - (\delta + g)k$

$k(0) = k_o > 0$

Here we have a fundamental differential equation determining the time path to be followed by the capital/labor ratio k.

The economy will attain a unique, stable equilibrium balanced growth path when $\dot{k} = 0$, that is, when $sf(k) - (\delta + g)k = 0$; K, L, and Y, grow then at the same constant relative rate g, that is,

(15) $\frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{L}}{L} = g$

because of $\dot{k}/k$ derived from equation (13). [2]

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1. Allen, R.G.D., Macro-Economic Theory: A Mathematical Treatment, Toronto: Macmillan, Co., p. 44.

2. This equilibrium is dictated by the conditions (9), (10) and (11) for all $k > 0$, which properties guarantees that K cannot grow indefinitely faster than L because L will ultimately become scarce enough relative to K to bottleneck future growth in k. See Burmeister, E., and A.R. Dobell, op. cit., pp. 23-36.

The growth rate g in Model I is unable to account, as it stands, for the observed current product growth rate $\dot{Y}/Y$ in developed economy, To reconcile the result given by (15) with the empiricial value of $\dot{Y}/Y$, the economic growth literature tried to solve the puzzle of the unexplained 'residual' by some kind of technical change component.

Allowing technical change, the production function takes the following form

(16) $\quad Y = F(K,L;t) \qquad F_t > 0$

with the same restrictions on F as above. This function represents disembodied technical change in either the form of Hicks-neutral or of labor-augmenting (Harrod-neutral) technical change.[1] We consider the Harrod-neutral (labor-augmenting) technical change. L is now measured in efficiency units. If g^* is a sum of a given rate of exogenous, labor-augmenting technical change λ and g, then in equilibrium

(17) $\quad \frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{L}}{L} = g^* = \lambda + g$

---

1. Hicks-neutral technical change can be shown to be $Y = G[a(t)K, a(t)L] = a(t)G(K,L)$ where a(t) is an increasing function of time. Technical change is Harrod-neutral if $Y = G[K, a(t)L]$. For discussion of technical change, see Hahn, F.R., and R.C.O. Matthews, op. cit., pp. 47-54 and Burmeister, E., and A.R. Dobell, op. cit., pp. 77-90.

But this Harrod-neutral technical change does not explain the 'residual' any better. Moreover,disembodied technical change is exogeneous, thus independant of Y. One, therefore should look at the introduction of endogenous technical change in a neoclassical growth model by including an additional factor-input in the form of human capital in the production function.

3.4 Model II: The Introduction of the Human Capital Variable in Model I Without Technical Change

We introduce a new variable H in the production function where H measures the level of human capital.[1] The production function then becomes,

(18) $Y = F(K,H,L)$

where H is assumed to grow endogenously according to how much Y is diverted into human capital. Differentiating with respect to time, Model I becomes

(19) $\dot{K} = s'Y - \delta K$

(20) $\dot{H} = hY - \delta' H$

(6) $\frac{\dot{L}}{L} = g$

where δ and δ' are the given constant depreciation rates and that s' and h are the two constant saving rates of physical

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1. The human capital variable H is measured by capitalization of wage differentials over and above the return to unskilled labor. See Griliches, Z., "Notes on the Role of Education in Production Functions and Growth Accounting", loc. cit., pp. 72-85.

capital and human capital respectively for which $s = s' + h$. It is also assumed that F exhibits constant-returns to scale in K, H, L and that F is a "well-behaved" continuous production function (see page 38-39). Defining $k=K/L$ and $k' = H/L$ and differentiating (18) with respect to time we are left with

$$\dot{k}' = hf(k, k') - (\delta' + g)k' \tag{21}$$

Thus the model will have a stable, unique equilibrium and the growth rate would be

$$\frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{H}}{H} = \frac{\dot{L}}{L} = g \tag{22}$$

Thus, at the equilibrium K and H must grow at the same rate g. And, as k and k' rise, the weak restrictions of F prevents them from rising indefinitely. The introduction of the variable H leads to the same problems as Model I and does not explain, therefore, the observed increases in output per capita on the equilibrium path. The residual is thus still left unexplained despite the inclusion of H in the production function.

3.5 Model III: A Modified Growth Model with Endogeneous Labor Component and Harrod-Neutral Technical Progress

We assume a neoclassical production function with technical progress of the labor-augmenting type:

$$Y = F(K,N;t) = G\left[K, a(t)N\right] \quad G_{a(t)} > 0 \tag{23}$$

where G is homogeneous of degree one in both factors and that the function is subject to $a(t) = 1$ at $t = 0$

$a(t) > 0$,

$a'(t) > o$ for $t > 0$

By analogy to technical progress we introduce the human capital variable which is thought to be equivalent to labor-augmented 'quality' index. Equation (23) becomes

(24) $Y = G(K, EN)$

where N is the number of workers used in producing Y, and E is a 'quality' productivity index in the form of human capital index multiplier embodied in workers.[1] Thus E is introduced in the Model to take account of N which may grow both endogeneously and exogeneously. Differentiating (24) with respect to time, Model III becomes:

(19) $\dot{K} = s'Y - \delta K$

(25) $\dot{E} = \frac{hY}{N} - \delta' E$

(26) $\frac{\dot{N}}{N} = g$

Since a(t)N in equation (23) may be identified as 'efficient labor', the first term on the right of equation (25) takes

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1. For computation of the E index see Griliches, Z., op. cit., pp. 75-76. Note that no adjustment is made here for "ability". If a large protion of the observed growth can be attributed to education, this should not be interpreted as implying that all of it has been produced by or can be attributed to the educational system. See Ibid., pp. 92-104.

an "efficiency" dimension and hY/N is measured in terms of "efficiency units".

Defining L = EN, equations (25) and (26) become[1]

(27) $\dot{L} = hY - (\delta' - g)L$

More compactly

(28) $Y = G(K,L)$

(19) $\dot{K} = s'Y - \delta K$

(27) $\dot{L} = hY - (\delta' - g)L$

Thus, in this form, Model III allows for endogeneous growth components of K and L, that is, s' and h are strictly positive.[2]

Thus, if L is a relevant and correct measure of the "quality-corrected" labor force, Model III suggests (given the same restriction on G and the parameters as in Model I and II) that the economy will approach a unique, stable equilibrium path on which all variables grow at the same relative rate, that is, a path on which k = K/L is constant and which is consistent with Harrod-neutral progress.

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1. L is thought to be a "quality-corrected" labor force and equation (27) is obtained by letting L = EN + EN. Substituting for (25) and (26) and solving we get (27).

2. As opposed to equation (6) where, in a world with no technical change, labor is assumed to be growing entirely exogeneously, equation (27) shows that labor may also grow endogeneously. The parameter h is thought as reflecting the endogeneous population growth responses to labor-augmenting technical change. See Griliches, Z., " A Modified Neoclassical Growth Model with Endegeneous Technical Change", loc. cit., p. 200.

$k = K/L$ is the capital/labor ratio and $\dot{k}/k$, the relative rate of change, is defined as

$$(29) \qquad \frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \frac{\dot{L}}{L}$$

Dividing both sides of (19) and (27) respectively by K and L and manipulating we get

$$(30) \qquad \frac{\dot{K}}{K} = \frac{s'G(K,L)}{K} - \delta$$

$$= s'f\left(\frac{1}{k}\right) - \delta$$

$$(31) \qquad \frac{\dot{L}}{L} = \frac{hG(K,L)}{L} - (\delta' - g)$$

$$= hf(k) - (\delta' - g)$$

Substituting (31) and (30) into (29), the equilibrium solution determining the time path to be followed by k is given by

$$(32) \qquad \frac{\dot{k}}{k} = s'f\left(\frac{1}{k}\right) - hf(k) - (\delta - \delta' + g)$$

In equilibrium, and by constant-returns to scale assumption, K, L, and Y grow at the same rate. Calling this rate Ω

$$(33) \qquad \frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{L}}{L} = \Omega > g$$

Given the function G, Ω(a constant) depends on the parameters of equations (19) and (27) and may be noted

$$\Omega = \Omega(s', \delta, h, \delta', g).^{1}$$

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1. From the assumption $h > 0$, $\Omega > g$. L being defined to be equal to EN, and taking the per capita rate of change in $\dot{L} = \dot{E}N + E\dot{N}$, we have $\frac{\dot{L}}{L} = \frac{\dot{E}N}{EN} + \frac{E\dot{N}}{EN}$ where $\frac{\dot{E}N}{EN} > 0$ and $\frac{E\dot{N}}{EN} = g$. Ω is proven to be homogeneous fo the first degree with partial derivatives of signs $s'(+)$, $\delta(-)$, $h(+)$, $\delta'(-)$ and $g(+)$. The form of Ω is implied by the function G. However, an explicit solution of the Ω-function is difficult. See Conlisk, J., " A Modified Neoclassical Growth Model With Endogeneous Technical Cange", op. cit., p. 203.

Then as opposed to Models I and II, Model III, (and the result of (33)) could explain the 'residual' between the observed growth rate $\dot{Y}/Y$ and the population growth rate g. This result depends on the existence of endogeneous technical change in the sense of "quality-corrected" labor-augmented force.

3.6 Limitations and Concluding Remarks

The solutions of our aggregated models are long run equilibrium. Thus, on an empirical basis, long run aggregate data should be required. This raises serious conceptual and empirical difficulties as far as Model III is concerned in estimating $Y = G(K, L)$.

The human factor is hardly measurable. In the production function, man is thought of as consisting of labor and a particular level of embodied human capital. The human factor should include then, all the elements which, together with capital and labor determine what the level of Y output will be. For the purpose of analysis, human capital (in terms of labor-augmented "quality" index) was assumed to be homogeneous. But one should be aware that there is a collection of human capital assets and then, an aggregation problem. This difficulty is amplified by the investment-consumption dichotomy problem which does not occur in the

case with physical capital. Capital embodied in man for consumption purpose may not be distinguishable from investment in human capital. [1]

The concept of human capital as a factor in the aggregate production function is also subject to substitution and complementarity. In most classical production functions, physical labor and physical capital are completely substitutable. [2] Limiting our thought to only one kind of labor, that of"skilled"labor, it is possible and plausible to presuppose that physical capital is more complementary with 'skill and knowledge' embodied in labor than it is substitutable. [3] This could be plausible on a theoretical basis, but still that it is limited because of aggregation difficulties. In examining the production processess, one

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1. This problem of investment-consumption dichotomy will be discussed in the next chapter.

2. Attention has been given to constant-elasticity of substitution (CES) production functions, described in per capita variabled. The Cobb-Douglas production function is a special case of the CES functions, where there exist a unit elasticity of substitution. For theorical and empirical discussion on Cobb-Douglas and CES function see Walters, A.A., "Production and Cost Functions", Econometrica, 31 (January/April, 1963), pp. 2-66; Dobell, A.R. (ed.), " A Symposium of CES Production Functions". Review of Economics and Statistics, 50 (November, 1968), pp. 443-479; and Burmeister, E., and A.R. Dobell, op. cit., pp. 8-64.

3. As a consequence of our Model III, that $K/K = \mu > g$, this would imply also a growth in the relative demand for "skilled" labor.

should look at the different amounts of human capital needed to operate the processes in combination with physical capital. Only dissagregation of the basic data into different categories of human capital might clarify the questions of substitution and of complementarity.

As a concluding remark, human capital is regarded as a driving force in the process of economic growth and certainly deserves a much greater attention than received. As shown in Model III, the problem of the 'residual' left unexplained in most standard neoclassical growth models, could be solved by capital embodied in human agents. Thus, there exist factors (like education, the largest source of human capital) that, together with physical capital and labor, could explain growth in output. But still aggregation of the total stock of human capital faces serious difficulties. It is to be hope that measurement problems could be overcome.

If the individuals are considered as producers of goods and services, the concept of human capital could provide an adequate measure of labor's productive inputs, valued in terms of the flow of goods and services labor helps to produce. By analogy with the theory of investment in physical capital, labor's productive capacities can be augmented.

Human capital formation can take many forms: education (both formal and on-the-job) help to produce productive skills; health and safety expenditures can lenghten and preserve productive lives. These investment in human capital are, among others, the most obvious forms of human capital investment decisions.

Chapter 4. INVESTMENT IN HUMAN CAPITAL: A MICROECONOMIC ANALYSIS

4.1 Introduction

In the preceding chapter we have stressed the importance of human capital as a factor of production and seen that human capital is likely to be as important as physical capital in explaining growth. This chapter will be concerned with investment in human beings. Since people have acquired abilities that have economic values which usually entail identifiable costs, the process of acquiring these 'qualities' that yield future income should have the attributes of investment. Especially, since the labor force incorporates both quantitative and qualitative dimensions, any expenditure on labor that increase his future productivity, should be thought as an improvement in the 'quality' of the labor force over time and yield positive returns.

When dealing with investment in human capital we are faced with the question of how accumulation of human capital could improve future productivity of man. If physical capital formation is thought as consisting of additions to real physical capital in the form of reproducible instruments of production, the commitment of resources which make addition to the stock of human capital is, by analogy, thought as

being investment in human beings. This concept of human capital formation rests on the premise that man is improved by investment in the stock of human capital and that the outlays of resources made should yield, in principle, a continuing return over time.[1]

In principle, the measurement of the magnitude of human capital formation or the value of its productivity is estimated by "following the practice followed in connection with physical capital goods".[2] Because of conceptual and practical difficulties raised by the allocation of several classes of expenditures between investment and consumption, the measurement of human capital formation by expenditures is, however, less useful than for investment in physical capital goods.[3] The method that is widely used regards the present value of human capital formation as determined by discounting the additional future income stream at the market rate of interest.

In the foregoing analysis we will be concerned with some aspects of production of human capital assets. After examining one specification of the costs of investing in human

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1. The returns are the earnings that are associated with a particular investment in man.

2. Schultz, T.W., "Investment in Human Capital", loc. cit., p. 8.

3. Ibid., p. 8.

beings we will emphasize the profitability of such investment. Human capital formation brings returns as investments in physical assets do. But one must keep in mind that this analysis is based on an analogy only and that one must be careful in the interpretation of its results due to the conceptual and practical difficulties and limitations in the theory of human capital.

4.2 The Cost of Producing Human Capital [1]

Using a microeconomic approach, we assume that a typical individual has the opportunity to acquire skill and knowledge which will improve his future productivity. This opportunity involves an investment cost which has to be estimated.

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1. The theoretical analysis of investment outlays in human capital and the optimization process of producing human capital "output" will be based on the contributions of Becker, Mincer and Ben-Porath. See: Becker, G.S., "Investment in Human Capital: A Theoretical Analysis", Journal of Political Economy, Supplement, 70 (October, 1962), also Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education, loc. cit., Mincer, J., "On-the-Job Training: Costs, Returns and Some Implications", Journal of Political Economy, Supplement, 70 (October, 1962), Ben-Porath, Y., "The Production of Human Capital Over Time", W. Lee Hansen (ed.), Education, Income and Human Capital, loc. cit., pp. 129-151.

We first list the assumptions of the theoretical model explaining investment in human capital over time.

i) The individual is thought to behave as a firm and possesses knowledge of the values of all the relevant variables in equations (1), (3) and (5) with perfect certainty.

ii) A perfect capital market exists in which the individual can borrow funds and lend unlimited amount at a fixed and given market rate of interest i.

iii) The price of the labor input and the 'rental' service of the individual's human capital product are determined in perfectly competitive markets and are fixed and given insofar as the individual is concerned.

iv) The production function (3) is subject to diminishing returns with regard to the homogeneous stock of human capital and time input.

v) The individual seeks to maximize the present value of his earnings net of all his investment outlays.

Ben-Porath defined the current earning E(t) of the representative individual at time t by the following relation"

(1) $$E(t) = rH(t)$$

where H(t) the stock of human capital at time t assumed to

be homogeneous. Since man is assumed to have a finite working life, the length of which is known with certainty, r is defined as a measure of the 'price' or 'rent' which the individual receives per unit of time for the service of a unit of human capital. For simplicity, we assume that the individual expects that the 'rent' he actually receives per unit of investment remains constant through its working life.[1]

Since the individual has the opportunity to increase his own human capital stock (H), the production of human capital can be expressed in a neoclassical production function of the Harrod-neutral factor augmenting type.

(2) $Q = F(H, R, t, T)$

Q is the flow of human capital

H is the human capital stock

R is other inputs

T the working life time.

Following Ben-Porath we introduce the "neutrality hypothesis" according to which a human asset "increases productivities in the market at the same rate as it does in the

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]. Ben-Porath, Y., "The Production of Human Capital Over Time", loc. cit., p. 130. If the individual, as productive labor incorporating both quantitative and qualitative dimensions is thought to be made up of "one unit of raw labor and some particular level of embodied human capital", the earnings he receives per unit of time can be viewed as $w = w_o + rH$ where w_o is the market price for raw labor and r is the 'price' or 'rent' of his embodied units of human capital. See Griliches, Z., "Notes of the Role of Education in Production Function and Growth Accounting", loc. cit., p. 90. If H can be measured, then the above equation can be solved for r.

production of additions to the stock of human capital"[1]. This "neutrality hypothesis", combined with Harrod-neutral technical change, yields:

(3) $$Q(t) = G\,[k(t)H(t),\ R(t),\ T]$$

As for physical stock, it can be argued that investment in our typical individual's human assets constitues an addition to his capital stock measured in some sort of homogeneous unit, resulting from the combination of two inputs: $[k(t)H(t)]$ is some proportion of service of human capital which is devoted to the production of new human capital. If time is allocated only between perfect labor market and human capital production, it is assumed that:

(4) $$0 < k < 1$$

where $k(t)$ is expected to be a decreasing function of time with the restriction that $k(t)$ declines to zero at a given market retirement age T, determining, then, the pattern of investment behavior of the individual in his human capital stock over time.[2]

The opportunity to increase the production of human capital stock by one unit involves a total cost composed of direct outlays (ℓR), where ℓ is the unit price of other

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1. Ibid., p. 148. See also Mincer, J., "The Distribution of Labor Incomes: A Survey With Special References to the Human Capital Approach", Journal of Economic Literature, 8 (March, 1970), p.11

2. Ben-Porath, Y. loc. cit., p. 131. See also Johnson, T., "Returns from Investment in Human Capital", American Economic Review, 60 (September, 1970), p. 551.

relevant market resources and of indirect outlays such as foregone earnings (rkH) of choosing to invest rather that choosing an acitivity that requires no investment. Gross investment expenditures KH (t) are expected to be greater than zero for each investment period $t < T$. The unit cost-minimizing factor combination is given by

(5) $$\bar{C} = r\bar{k}\bar{H} + \ell R$$

where $\bar{H}$ and $\bar{R}$ are such that $\bar{C}$ is a minimum. It is also assumed that investment outlays are expected to rise with the rate of production at a decreasing rate, that is, equation (3) is assumed to exhibit decreasing returns to scale. Thus, the function G is assumed to be homogeneous of degree $\rho < 1$ in H (t) and T. From equations (3) and (5), total investment outlays of producing output of human capital stock is given by:

(6) $$C(Q) = \left(\bar{C}Q\right)^{1/\rho} = Q\left[rkH + \ell R\right]$$

and the upward sloping marginal cost curve by

(7) $$\frac{\partial C(Q)}{\partial (Q)} = \frac{1}{\rho}\left(\bar{C}Q\right)^{\frac{1-\rho}{\rho}} = \frac{1}{\rho} Q\left[rkH + \ell R\right]$$

Reinforced by the assumption of diminishing returns, the marginal cost function (7) gives one of the elements which will determine the optimum rate of producing additional units of human capital Q (t). As to trace the time pattern of investment outlays we need to value the expected future earning capacity.

4.3 The "Profitability" of Investment in Human Capital Assets

From the point of view of the representative individual, the capital value of his human capital stock can be measured by the usual method of valuing physical capital assets. In principle and for methodological convenience, one of the criteria is to find the present value of expected future gross earnings (E) less the investment outlays (C) by capitalizing at the current rate of interest.[1] If we assumed that the individual is governed by "rational" calculation, he is expected to maximize his anticipated earnings by equating the present value of future earnings to the investment outlays in his human stock.

We define a competitive equilibrium in the human capital market if for a positive expected working lifetime T, there exist a discount rate at which the net present value [PV] of all investments in each period is maximized. From equations (1) and (5), net earnings (N) of the individual is defined as

$$(8) \qquad N(t) = E(t) - \bar{C}(t) = rH(t) - \bar{C}(t)$$

where N(t), assumed to be positive, is defined on some inter-

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1. See Chapter 5 for discussions on the criteria of investment.

val of time t($0 \leq t \leq T$). Net earnings mean gross earnings during any period of time net of all investment costs during the same period. With the given rate of interest, the capitalized value of the individual's income stream at time t will be uniquely determined. Thus, the present value, given as a function of time and the market rate of interest, is

$$(9) \qquad PV(t) = \int_t^T N(\tau) e^{-i(\tau - t)} d\tau$$

Assuming that the investment made at time $\tau \leq t$ depends upon the expected future income streams and providing that the expected life of the money returns of the investment outlays at t does not exceed the retirement age (T - t) from the labor market, then, from equation (9) the individual will maximize the anticipated net earnings of an extr. unit of human capital that earns r by setting the partial derivative of (9) with respect to time t equal to zero. By assuming, for simplicity, that the earnings are the same in each period, we obtain:[1]

$$(10) \qquad \frac{\partial PV}{\partial t} = p(t) = \frac{r}{i}\left[1 - e^{-i(T - t)}\right]$$

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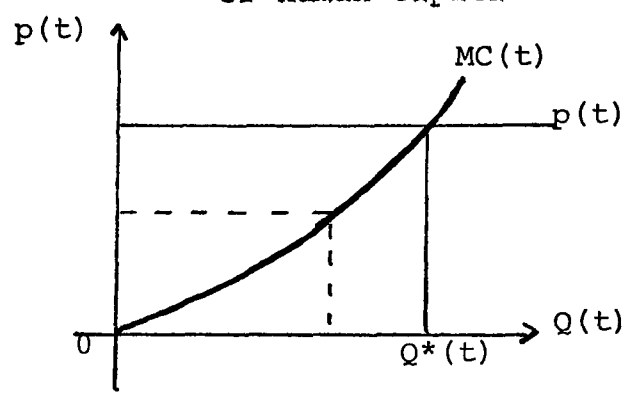
1. Ben-Porath, Y., loc. cit., p. 132. The same result is obtained by Becker, G., Human Capital, loc. cit., pp. 38-39 where he used discrete income flows and compounding rather than formulating his discussion in terms of continuous variables.

As for conventional physical capital, this asset should command a price equal to the present discounted value of its flow of earnings.

Under the "zero-profit" maximizing relationships, the discounted stream of net earnings [p(t)] should exactly covers the cost of producing an extra unit of human capital. This situation can be expressed graphically.

Figure 1 - The Optimal Rate of Production of Human Capital



Let MC(t) ≡ marginal cost and p(t) ≡ the anticipated marginal return of an additional unit of human asset under perfect competition. Under the assumption of diminishing returns, the cost of acquiring an extra unit of human capital stock (H) increases with the rate of production Q(t): thus the MC curve is sloping upward. Hence, the returns are maximized (ceteris paribus) when the marginal present value of the assest equals the marginal increase in human capital cost. Then the optimum rate of producing the human capital

stock [Q*(t)] will be that rate for which p(t) = MC(t),[1] or

$$(11) \qquad Q^*(t) = \frac{\partial PV}{\partial t} - \frac{\partial C(Q)}{\partial Q} = 0$$

From equation (7) and (10), we have

$$(12) \qquad \frac{r}{i}\left[1 - e^{-i(T - t)}\right] = \frac{1}{\rho}\left(\bar{C}Q\right)^{\frac{\rho}{1-\rho}}$$

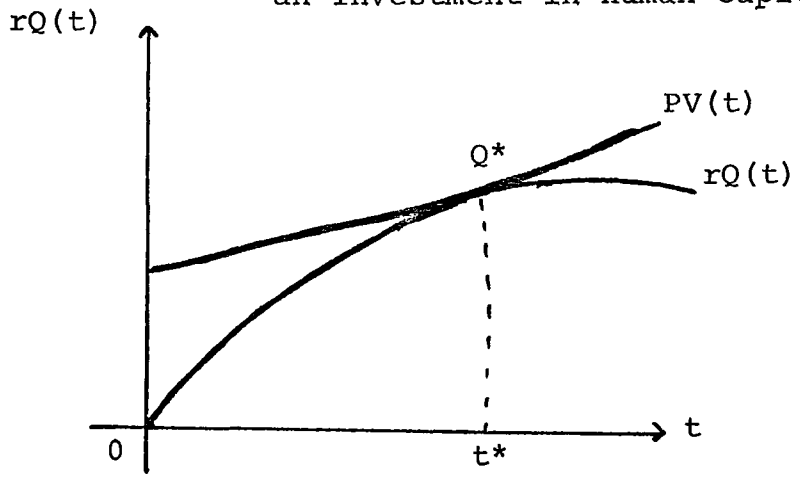
Rearranging and solving for Q*(t) we are left with

$$(13) \qquad Q^*(t) = \left\{\frac{\rho}{i}\frac{r}{\bar{C}}\left[1 - e^{-i(T - t)}\right]\right\}^{\frac{\rho}{1-\rho}}$$

The optimum rate of production [Q*(t)] deserves some attention with respect to the optimum length of production period. From the assumption of diminishing returns in G and from equation (6), we can expect that the investment outlays of acquiring human capital stock presumably would be expected to increase with the production level required, and perhaps at an increasing rate. Thus, the individual will invest until the point where diminishing return reduce $r\left[1 - e^{-i(T - t)}\right]$ on the marginal dollar 1/MC to equality with the market rate of interest. This condition (which maximizes the discounted value of his net earnings) can be illustrated graphically.

]. The idea of equating the two sides of equation (12) is nothing but the same as equating marginal cost with marginal revenue in perfect competition.

Figure 2 - The Maximum Present Value of an Investment in Human Capital



We plot dollars of revenue on the vertical axis and time on the horizontal axis. The curve rQ(t) is the quantity of human capital produced in time t, multiplied by the market "rental" per unit of human asset. This current value results from the net addition to earning capacity for each period resulting from investment outlays at time t.[1] The curve labeled PV is an "isopresent" value contour for a given rate of interest (i). The discounted present value is expected to rise with t since $e^{-i(T - t)} > 0$. Clearly, the highest present value [PV] attainable when constrained by the production function Q(t) is the optimal point Q*. The tangency point is given by equation (11), and one can read off the optimum length of production period t* and the corresponding maximum discounted value of the individual's

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1. Ben-Porath, Y., op. cit., p. 146.

earning capacity.[1]

Having established, in the above discussion, the equilibrium optimum rate of acquiring additional unit of human capital stock [Q*(t)] that maximize the discounted value of earnings, Ben-Porath goes on in deriving the time profile of the investment outlays devoted to the production of human assets.[2] Substituting the result of equation (13) into the total costs function (6), the investment profile is given by:

$$(14) \qquad C(t) = \left(\bar{C}Q^*\right)^{\frac{1}{1-\rho}} = \bar{C}\left\{\frac{\rho}{i}\frac{r}{\bar{C}}\left[1 - e^{-i(T-t)}\right]\right\}^{\frac{1}{1-\rho}}$$

Because of the expected decline in the time input [k(t)H] into the production of human capital related to the finite life span T, the relative rate of decline of investment over time becomes:

$$(15) \qquad \frac{\dot{C}}{C} = \frac{-i}{1-\rho}\,\frac{e^{-i(T-t)}}{\left[1 - e^{-i(T-t)}\right]} < 0$$

Of course, condition (15) depends heavily on the above discussion that both the rate of human capital production and investment outlays decline with time t (as $t \rightarrow T$). More-

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1. Conversely, it could be read off the maximum internal rate of retunr associated with t*, assuming a given discounted value (the internal rate of return being defined in terms of present value of net earnings).

2. Ibid., p. 130.

over, it is reinforced by the proper shape of the production function G and by the maximum conditions (12) and (13) from which the second-order conditions ensures that the marginal returns from investment with respect to time are decreasing and the marginal fixed cost of human capital be increasing — that is, from $\partial^2 PV/\partial t^2 < 0$, investment must be decreasing.

Underlying the specification of changes in C(t) over time, which traces out the individual's time profile of investment given by the relations (14) and (15), is the relation between the "neutrality" hypothesis and the time of investment outlays. The life pattern of the individual's investment behavior could be explained along the marginal cost curve (Figure 1). The first and second-order conditions of the optimization process described above explicitly implies that the returns from investment in each period of time $t(0 \leqslant t \leqslant T)$, along the fixed MC curve are declining, thus, responsible for a decrease in investments.[1] Generally speaking, the relative decline of marginal returns may be reinforced by a shift of the MC curve to the left as $t \rightarrow T$. Since the opportunities to increase the stock of human capital depends on [k(t)H(t)] and that the total investment

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1. Ibid., pp. 141-142, and Mincer. J., "On-the-Job Training: Costs, Returns and Some Implications", loc. cit., pp. 10-11.

outlays[$\bar{C}(Q)$] is independant of the homogeneous capital assets H of the individual, this situation holds for $k(t) < 1$. There is a labor force participation, that is, part of the human capital stock available is allocated to investment in human capital. If the individual is more productive in the labor market than in the production of human capital assets, the fractions of time invested k(t) becomes more expensive; earnings are then greater in the labor market and investment is declining over time.

The whole analysis could suggest an early concentration of human capital formation. Indeed some incentives could explain this situation:

i) The individual is assumed to have a finite working life. From the result (15), investment outlays are spread over many periods because MC (Q) is increasing for all $t(o \leqslant t \leqslant T)$, thus, expecting smaller returns over a short period from later outlays. Then, the earlier the human capital is acquired, the longer could be the working life of the individual. As Ben-Porath explained it, in the earlier life the individual inyests all his time imput; that is, his stock of human capital is relatively small

and he invests his entire earning capacity.[1] In this phase periods (where k(t) = 1, with no labor force participation) human capital formation is expected to rise during the early stages.

ii) The second incentive is directly connected with the first one. The opportunity cost of investment increases with time. Because of the importance of time input in Q(t), investment outlays increase the value of foregone earnings (rkH). The investment in later assets is more constly, as $t \rightarrow T$. Thus one could expect an early concentration of human capital formation of the desired rate of human capital stock.[2]

The general consequence of the investment profiles is that the pattern of the investment behavior can be translated into earnings profiles over time.[3] Net earnings has been earlier defined (8) as the gross earning capacity minus all investment outlays. Net earnings are also expected to rise

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1. Ibid., p. 134.

2. We should keep in mind, however, that the analysis of Ben-Porath is confined to the phase where $k(t) < 1$, that is, the "enutrality" hypothesis hold only for labor force participation in the building up of human productive capacity.

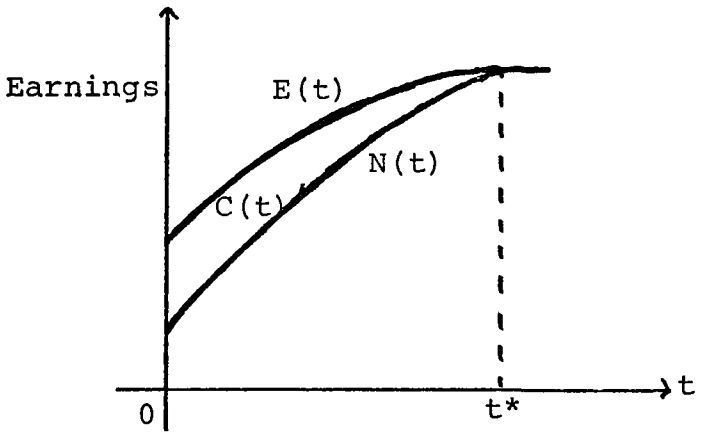
3. Ibid., p. 133.

with time t. Computing $dN(t)/dt$ from (8),

$$\dot{N}(t) = rQ(t) - \dot{C}(t) > 0 \qquad (17)$$

This result own both to the current value of human capital stock and the decline in investment outlays (15). Differentiating $d\dot{N}(t)/dt$ we are left with $\ddot{N}(t) < 0$, meaning that $N(t)$ rises at a declining rate.[1] This earning model can be illustrated graphically.

Figure 3 - Net Earnings Time Profile of Human Capital Formation



The two axes represent earnings and working life respectively, and the earnings profiles are function of age t. $E(t) \equiv$ gross earnings and $N(t) \equiv$ net earnings: Both are assumed to have a proper shape for the representative individual. For all $0 < k < 1$ the earnings profiles are upward sloping and concave. For $t \geq 0$, investment expenditures $C(t)$ are spread over time in order to improve his future earning streams.

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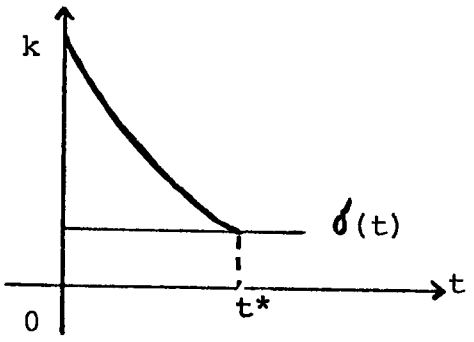
1. Ibid., p. 133.

These earnings are increasing at a decreasing rate [$\ddot{N}(t) < 0$] as a consequence of the decline of investment outlays over time (15). The maximum of earning capacity is found at $\dot{N}(t) = 0$ that is, investment expenditures must be zero at t*. Thus, for $k(t) < 1$, the investment period is Ot*.[1]

From the result given by equation (15) and from the discussion of Figure 3, we can describe the pattern of investment in human capital

Figure 4 - Time Profiles of Human Capital Formation



Let us define k (the fraction of time input devoted to human capital "output") as an investment ratio of investment outlays to gross earning capacity. The human capital formation described above has been confined to gross investment expenditures. The model can be constructed in net investment terms if we assume that human capital stock depreciates. Let $\delta(t)$ be the rate of depreciation assumed here, for

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1. Mincer, J., op. cit., pp. 11-12 and Johnson, T., op. cit., p. 551.

simplicity, to be constant: $\delta(t) = \delta$.[1] If investment outlays proceed at $k(t) < 1$ (thus ignoring appreciation), the net investment ratio devoted to the production of human capital "output" [Q(t)] is, for all $t (0 \leq t \leq T)$

$$k(t) = rk(t) - \delta(t) \tag{18}$$

As gross investment decline over time, net investment decline also as k(t) approaches zero. If retirement from the labor force is compulsery at $T = t^*$, net investment must be zero for gross investment in human capital to attain a maximum at t^* and dropped almost to zero.[2]

4.4 Conceptual Difficulties and Limitation

Although it is interesting to see, at the conceptual level, how the human capital concept provides a useful analytical framework for attempting to understand the relationship between human capital formation and labor productivity and therefore, earning capacity; although it is worthwhile to emphasize the analogy of investment in physical capital

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1. The analysis also applies to $\delta(t)$ defined as a linear or exponential function of time (being more realistic). But because of "the lack of any compelling theoretical reason for a complicated fonctional form of $\delta(t)$, it is assumed that $\delta(t)$ is constant". See Johnson, T., op. cit., p. 550. And since the "rental" service r of human capital has been assumed to remain constant over time, it is convenient that $\delta(t)$ be assumed constant.

2. Mincer, J., op. cit., p. 13 and Johnson, T., op. cit., p. 551.

with the investment pattern in human capital that improves labor productivity and yield future returns; these relationships described in the above optimazation model still raise (in line with "reality") serious conceptual difficulties.

4.4.1 "Profit Motivations?

As a general agreement it is argued that human capital is not a negotiable asset. While additions to the stock of human capital become embodied in man and hence cannot be sold, they are nevertheless "in touch with the market place" by affecting labor productivity and future earnings.[1] Assessing the profitability of human capital formation is, in principle, quite different from assessing the one for physical investments. The costs of producing additional units of physical assets are usually known. It is quite easy, then, (apart from the question of the proper discount rate) to determine the value of physical capital assets by discounting the income streams.

In principle, the value of human capital formation can be determined just as the value of physical capital, but assessing its price is another matter. At the optimization stage, the level of human investment outlays can be quite different from the anticipated returns (or "profits"). Indeed there

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1. Schultz, T.W., "Investment in Human Capital", op. cit., p. 8.

may exist no simple and necessary relationships between the cost of producing human capital and its economic value.[1] This is especially true when considering cost incurred for education, part of which may not have been undertaken with a view to profit. Although investment outlays may be estimated, there exists pratically no means of determining what fraction of time k will be devoted to the production of human capital, and part of the total investment expenditures may not be minimized in view of maximizing his earnings returns. Thus people may not be considered as "profit" maximizer".[2]

4.4.2 Depreciation

When dealing with investment in physical capital assets, allowance for depreciation is usually made, thus assuming that the physical assets depreciate at a certain rate over their expected life time. If no general agreement exists on how to treat depreciation and if its calculation generally refers to a kind of accounting system, assessing a rate of depreciation to human being is another matter.

Gross returns on inyestments are expected to fall and eventually fall to zero at the age of retirement. Then one

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1. Kiker, B.F., The Concept of Human Capital, loc. cit., p. 16.

2. See also discussion on investment-consumption dichotomy, pp. 71-74.

should expect the net earnings streams to be the depreciation rate. For simplicity, the problem of depreciation could be avoided by assuming implicitely that it "constitutes a fixed fraction of earning capacity throughout life".[1] More generally, the capitalized expected income streams over the productive life span of the additional human capital "output" through investment outlays may take account of the depreciation factor on the investment by the loss of earning capacity to retirement. This amounts saying that earlier investment outlays are expected to yield greater returns over a larger period[2] and, at the age of retirement from the labor market, earning capacity is expected to decline at the time at which gross investment is outstripped by depreciation.[3]

4.4.3 Investment-Consumption Dichotomy

Although the human capital formation is expected to improve labor productivity by investment outlays in the individual's human capital stock; although the investment outlays made are expected to yield continuous returns over time; still the expenditures on human capital have to be broken down into two components: investment and consumption.

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1. Ben-Porath, Y. loc. cit., p. 150.
2. Kiker, B.F., op. cit., p. 18.
3. Mincer, J., op. cit., p. 13; and Figure 4.

The most serious problem that human capital theory has to solve, relates to the difficulties of distinguishing between human capital formation as a consumption good and as an investment good.[1]

Returns from investment outlays are generally well understood. But much less is known and understood about the concept of "returns" from consumption. What is the nature of such concept and how should it be measured? How the total cost of producing additional units of human capital output should be treated?

Physical capital stock can be valued in a number of ways (by the replacement cost...). Even if the physical asset is treated as heterogeneous, its value can sometimes be given by summing up each physical capital item valued in monetary terms. Productive labor is also heterogeneous (manpower, skill, talents and other intangible elements). Human capital is thus composed of a collection of assets with market and nonmarket significance of which some are either complementary or substitutes. Assets obtained as consumption goods may not be divided and used separately, and they may not be distinguishable from those obtained as investment in physical capital. In other words, this means that the earning capacity of the individual may not be separated from the returns due to

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1. Kiker, B.F., op. cit.,p. 19.

nonmarket factors that influence future human capital "output".[1]

If total costs (described by equation (5) are treated as investment outlays, the problem of allocation of costs between consumption and investment does not arise.[2] But to conceptually more realistic, part of the total costs are surely consumption in the sense that human capital formation creates a form of consumer durable that improved the intangible elements of human capital. The returns, however, are non-marketable and do not appear in the future earnings.[3] But since human capital is different of physical assets, since many of the heterogeneous components of productive labor are intanbigle elements, part of total investment outlays are not for "profit" motivations and are not identifiable in future human capital "output". These elements are for direct satisfaction of "wants" and are not included in the "rational" optimization process. Even if it were conceptually possible to distinguish consumption goods from investment goods still it will be "impossible" to allocate anticipated returns to each heteregeneous item of human capital that enhance

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1. Kiker, B.F., op. cit., p. 9 and Eckaus, R.S., "Education and Economic Growth" in M.J. Bowman (ed.), op. cit., p. 574.

2. We have assumed in the above model, that "the services of human capital as a durable consumption good are ignored, and so is the utility or disutility that may be associated with its production". Ben-Porath, Y., op. cit., p. 132.

3. Schultz, T.W., "Investment in Human Capital", op. cit., pp. 12-13.

future productivity of the individual. The problem of allocation is not solved yet, and we are left with only that part of human capital investment that has a tangible effect on earning capacity.

4.4.4 Market Imperfections

It was assumed that with a given rate of interest, the individual can borrow funds and lend indefinitely. If this assumption is relaxed, that is, if we introduce financial constraints, risk and uncertainty, the study of human capital formation becomes more complicated.

As mentioned above, human capital stocks are embodied in man. Human capital cannot be sold, and cannot be considered as a liquid asset. Hence, "not being property, it cannot be owned jointly by the person in whom it is embodied and others".[1] It is then rather difficult to borrow funds for investment in human capital because human capital assets cannot be offered as collateral for loans.[2] This raises imperfections in the financial market required to finance investment in human capital. Human capital formation is long-run, and it has either a relatively longer

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1. Goode, R.B., "Adding to the Stock of Physical and Human Capital", American Economic Review, Supplement, 49 (May, 1959), p. 152.

2. Becker, G.S., Human Capital, loc. cit., pp. 55-56.

life than investment in physical capital.[1] If the production for physical investment allows for perfect knowledge, it might not be the case for human investment. Because of uncertainty, the individual's production function for additional units of human capital may become less efficient. Factors like the length of life, the length of working life, the expected abilities and some other unpredictable events may reduce the knowledge available about the efficiency of the production function with the possibility that the actual returns from investment outlays vary around the expected returns;[2] making then uncertain the expected present value of earning streams. In this case the individual should not be able to obtain the optimum rate of production of additional human capital assets.

4.5 Concluding Remarks

By analogy with investment in physical stock, this chapter was concerned with human capital formation. Under specific assumptions, the underlying principle was that the individual has the opportunities to enhance his productivity by investing in his productive capacities. Summarized

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1. Schultz, T.W., "Investment in Human Capital:Reply", American Economic Review, 51 (December, 1961), p. 1036.

2. Becker, G.S., op. cit., p. 55.

in a production function, these opportunities have the attribute of yielding earning streams over time. From the optimizing behavior assumptions, an optimum rate of human capital production has been derived, giving them an analytical framework to study the investment and earnings profiles over the individual's productive life span. But when certain assumptions underlying the optimum model are relaxed, the whole analysis faces serious difficulties (conceptual as well as empirical). Facing these limitations, the analysis must be concerned with the aggregation problem, the depreciation factor, the investment-consumption dichotomy, and the imperfect financial market that serve investment in human capital.

The optimizing behavior assumptions works well for physical capital formation, it is not so clear for investment in human capital. Further research is needed with respect to the measurement and the conceptual clarification of the various elements of human capital assets. The central difficulty may be that of the investment-consumption dichotomy. The allocation of expenditures to each good (capital and consumption) and the computation of returns due to each heterogeneous item of human assets is not an easy taks. Some hopes may be claimed, however, concerning the breaking down of the components of human capital and examining seriously the interrelationships among the tangible and intangible elements of human capital.

The individual's investment decision has been investigated under the assumption of a perfect market economy. In studying the responses of individuals to invesments opportunities in, say, road safety, that lengten and preserve their productive capacities, one should born in mind that the production or the supply of safety, as a form of human capital, faces many market imperfections. Furthermore, safety appears to many individual to be the dual of risk. In the hope that safety will decrease the risk of being killed or injured in automobile accidents, the effect of safety on individuals' productivities seems evident in that it, ceteris paribus, preserves human capital. However, safety has also a consumption aspect. The effect of safety could be for satisfaction of consumer well-being in either present or future consumption, accompanied by a relative strong desire of being alive before and after the retirement age. Any attempt to explained the individuals' behavior with regard to their investments in safety appear to be beyond the scope of conventional private market economics. Society may wish to alter individuals incentives to either to consume or to invest in safety through the supply of social goods, and methods of analysis must be found which will promote efficient allocation of resources to traffic safety.

Chapter 5. TRAFFIC SAFETY AS A PUBLIC INVESTMENT

5.1 Introduction

Micro-economic analysis is mostly concerned with the conditions that must be met if the private market economy is to function efficiently, that is, is to achieve perfect competition. We recall that (1) convex indifference curves, (2) nonincreasing returns-to-scale in all industries, (3) exclusion property,[1] (4) perfect knowledge in the production and consumption sets, in the price and (5) perfect mobility,[2] are the conditions that must be satisfied. Only if all these conditions hold will the consumers' and the producers' choices and the forces of competition assure that the allocation of resources determined through the market is socially optimal.[3] In the real world, however,

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1. For a good to be exclusive, everyone but the buyer of the good must be excluded from the satisfaction it provides.

2. For a review of the basic principles of perfect market operations, see Haveman, R.H., The Economics of the Public Sector, New York: John Wiley & Sons, 1970, pp. 17-30. See also Steiner, O., "The Public Sector and the Public Interest", in Haveman, R.H. and J. Margolis (eds.), Public Expenditures and Public Analysis, Chicago: Makham Publishing Co., 1970, pp. 26-33; Arrow, K.J., "The Organization of Economic Activity: Issues Pertinent to the Choice of Market Versus Nonmarket Allocation", in Haveman, R.H. and J. Margolis (eds.), op. cit., pp. 61-64.

3. Social optimum is defined as a situation in which it is impossible to increase the welfare of any individual without decreasing the welfare of some other individuals.

markets are not perfect. The exclusion principle is often violated and many goods and services are supplied through public or government action replacing individuals decisions. Markets fail to provide goods and services such as traffic safety "commodities", and a collective concern through public action is required to provide such services that are understood to preserve human capital. Market prices are unable to assure efficient allocation of resources and techniques are required to evaluate government actions that use resources to restore the social optimum.

5.2 The Nature of Traffic Safety

For goods and services that are marketable and, for which a competitive equilibrium exists in both factors and products markets, economic efficiency is achieved if there is no collective good and no externality (external economy or diseconomy), among others. For public goods and services, however, the existence of a price system determined by the market mechanism that will maintain such efficient allocation is not in general satisfied. Social intervention may be necessary, then, to assure or approximate social optimality.

Government intervention is sometimes necessary for the production of social good for which individuals preferences are not revealed through the market place. These goods are

defined as "good which are non-rival in consumption",[1] that is, for which an increase in an individual's consumption does not decrease the others' consumption. Secondly, social good are not subject to the exclusion principle.[2] If an activity "affects the welfare of outsiders regardless of their desires"[3] the exclusion principle does not hold and such activities provides externalities that cannot be appropriated (as opposed to marketable economic good). These externalities usually accrued in the form of joint product in consumption or in production.

Let the government invest in a highway system (and in related human and technological factors) that could be designed to reduce the incidence of automobile accidents, deaths and injuries. Such investment is obviously to be regarded as a social good. If benefits from such road safety "commodity" exist for one individual (or road user), they would exist for all. If such "commodity" exists, it cannot be produced and sold by any private market economy,

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1. Musgrave, R.A., "Cost-Benefit Analysis and the Theory of Public Finance", Journal of Economic Literature, 8 (June, 1970), p. 799.

2. See Haveman, R.H., op. cit., pp. 25-26, 34.

3. Shapley, L.S. and M. Shubik, "On the Core of an Economic System with Externalities", American Economic Review, 59 (September, 1969), p. 678.

even though it is socially desirable. For example, benefits may accrue to others from an individual's decision to improve his driving conditions as to reduce the risk of road fatalities, even if they do not pay for it. Such benefits are generally not considered by the individual himself in his decision. He cannot appropriate these external benefits because he does not own them in the ordinary sense. These benefits are not marketable and are of no direct concern to individual's decision. The market system fails therefore to capture the "willingness-to-pay" of those who are enjoying the indirect benefits through no individual decision in their own safety. Prices will lead, in general, to inefficient allocation of resource if the market system presents social goods and externalities.

5.3 Government Intervention

External benefits are benefits to society at large. Thus, society may wish to alter individuals' decisions by some government action that often becomes necessary to eliminate inefficiencies generated by inappropriate allocation of resource by private market economy, and to assure adjustment towards optimality.

Individuals may be aware of the accident fatality risks. They nevertheless choose to spend their money on something

else. With different psychological make-up and different sociological relationships between them, individuals may substitute traffic safety for other "goods". Many times, for example, individuals' decisions to drive an automobile increase the risk of death or injury to himself as well as to others on the road; and many times also, individuals substitute safety for higher speed. From the diversity of individuals' preferences, conflicts arise, and group consensus is often impossible. As a socially desirable goal, road safety improvement call for government interference under many forms. Since it is not easy for individuals to "buy" traffic safety, public action is therefore entitle to provide such "commodity" for the satisfaction of all.

If the government is convinced that a public action is necessary to correct externalities, it can simply prohibit the action giving rise to it. This approach seems obviously poor: indeed, to stop traffic accident fatalities, one could not seriously propose that every car owner stops driving at once. There is, in effect, "a desirable level of automobile accidents-desirable, that is, from a broad point of view; in the sense that it is a necessary concomitent of things of greater value to society".[1] Automobile, in fact,

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1. Williams, J.D., "The Nonsense About Safe Driving", Fortune, 58 (September, 1958), p. 118.

has a large credit belance in the matter of lives and some "right" level of externalities may be needed to assure economic efficiency.

Another aspect of government intervention could take the form of regulation. An obvious response to the fact that cars contribute to raod fatalities is to establish or increase safety by regulation and/or by directive. For example, government may decide or require that all (new) cars be equipped with some safety devices designed to reduce or prevent car accidents. More generally, one could suggest that the government impose control over car, road, and human factors. A "right" mix of social regulations with control over traffic and automobile industry could be thought as overcoming inefficiency due to the nonmarketability of safety services. This should, in principle, not cause consumer to refrain from consumption. Difficulties arise, however, in that uncertainties as to whether government control over the accidents factor are effective in preventing road accident fatalities.[1] There is no simple and universally accepted solution. Government may indeed seek a pragmatic one to the choice of the best alternatives depending on the importance of the problem and the number of accidents involved.

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1. Taxes and subsidies, voluntary action, persuastion, government spending to eliminate external effect caused by individuals' actions are other forms of public interventions; see Haveman, R.H., op. cit., pp. 40-43.

5.4 The "Price" of Traffic Safety

For practical purposes, safety services are provided freely by government and financed by taxation. Should tax be the price of a social good provided by the government?[1] Differences between taxes and prices need attention. Taxes are generally accepted as compulsory payments by definition: governments must rely on taxation since he cannot support itself through voluntary contributions. Prices, or the choices of whether and how much to pay are ordinarily left with individuals' decisions. When individuals decide how much to pay, there is a direct relationship between payments and benefits they obtain, whereas taxes divorce payments from benefits. Individuals generally show more concern for private goods than for social goods but taxes create individuals concern for social goods. Taxes are also used to alter the skewness of income distribution. If taxes are not different from prices it could mean that higher income group pay higher price for equal service than low income group. Can we expect the same result to follow in the private market where all individuals pay the same price for equal service?

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1. For discussion, see Olson, M., The Logic of Collective Action, Cambridge, Mass.: Harvard University Press, 1965, pp. 13-16 and 88-97. See also Lees, D.S., "An Economists Consider Other Alternatives", in H. Schoeck (ed.), Financing Medical Care: An Appraisal of Foreign Programs, Caldwell: The Caxton Printers, 1963, pp. 52-75.

Public goods are, by their nature, consumed by all and they cannot be enjoyed separately and directly by individuals.[1] Determining the production and the distribution of traffic safety by means of a price is out of the question. Safety services must be available to every road user if they are available to anyone. The benefits of such good cannot be imputed to individuals and individuals can enjoy the effects whether or not they pay the price. Safety is provided collectively; if it has to be paid for, the most appropriate method is by compulsory taxes. This method permits the government to produce good and services that have value to a collectivity and offer social benefits that are shared

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1. One may object to safety as a public good equally consumed by all. But it may be contented that safety may be consumed inequally by different individuals and yet be a public good in the sense that one individual's consumption does not in any way decrease others' consumption.

by everyone.[1]

5.5 The Presence of Uncertainty and "Moral Hazard"

Government intervention is often necessary when perfect knowledge is absent from perfect competition. It is true that the incidence of traffic accident fatalities are unpredictable events and, sometimes very costly. Individuals in general are usually unable or unlikey to mainpulate risks to their own advantage. The problem is met through

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1. For a generalized "price" system in a public good economy, see in particular Foley, D.K., "Lindahl's Solution and the Core of an Economy with Public Goods", Econometrica, 38 (January, 1970), pp. 66-72. Foley states rigorously the modern theory of resource allocation with public goods by defining a public competitive equilibrium as an economy in which producers maximize their profits, in which consumers' satisfactions are maximized subject to the "after-tax budget" constraint, and in which there is no other "new public sector with taxes to pay for it" that will leave every individual better off. For discussion of this definition, see Foley, D.K., "Resource Allocation and the Public Sector", Yale Economic Essays, 7 (Spring, 1967), pp. 43-98, where a formal and axiomatic proof that such public competitive equilibrium, corresponding to a Pareto optimum, is given.

In such public equilibrium, the prices of social goods are identified to the marginal rates of transformation which rates are equal to the sum of every individuals' marginal rate of substitution at the Pareto Optimum (pp. 68-69). If taxes are introduced in the system to finance public expenditures, and if income is already distributed to achieve an ethical optimum the public equilibrium will correspond to the social optimum. Lindahl's solution to this optimum requires that the "value of public goods received by each individual is equal to the total tax he pays" (pp. 69-71).

the insurance market but many times the market is absent for provision of insurance against some uncertain events.[1]

In a well known article, K.J. Arrow is concerned with the problem of risk-bearing, especially in relation to the medical-care market.[2] Its relevance to traffic safety is as obvious as it is to health since, in both cases, illness or death (and injury due to automobile accidents) is an unpredictable event. The "ability to shift the risks" of being killed or injured "to others is worth a price which many are willing to pay". But many risks "are not covered and indeed markets for the services of risk-covering are poorly developed or nonexistent".[3]

Let safety be an intermediate social good, that is, "a good which enters into the production of further output" of a private good nature.[4] In that case improved road safety

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1. The use of mathematical theory of games could provide some tools for the study of such system. See Shapley, L.S. and M. Shubik, op. cit., pp. 678-684.

2. Arrow, K.J., "Uncertainty and the Welfare Economics of Medical Care", American Economic Review, 53 (December, 1963), pp. 941-973.

3. Ibid., p. 945.

4. Musgrave, R.A., op. cit., p. 800. The intermediate social good "has the same characteristic of non-rival use" as has the final good, but which is now "by producers rather than consumers". The benefits of such social good can be value efficiently at the market price "since it enters into a final private good".

measure could be expected to reduce hospital and medical care costs due to non-fatal injuries. Where the risks involved in automobile accidents (risk of being killed or injured) are not covered by the private market (whether risk-coverage is nonexistent or nonavailable), Arrow argued that government should undertake insurance against certain losses due to the cost of medical and hospital care, the losses of productivity due to disability, the losses of total deprivation of normal activity and also phsychic loss. The loss of welfare due to market failure to provide suitable insurance for either risk call for government action that could lead to optimality by eliminating the uncertain expenses by compulsory social insurance.[1]

Pauly commented that if "all individuals are expected utility maximizers and are risk-averters", insurance against automobile accident "may not be optimal". He then argued that "the fact that certain insurance have failed to emerge in the private market may not be no indication of nonoptimality, and compulsory government insurance against some uncertain events may lead to inefficiency".[2] If "moral

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1. Arrow, K.J., op. cit., pp. 958-961.

2. Pauly, M.V., "The Economics of Moral Hazard: Comments", American Economic Review, 58 (June, 1968), p. 531. See also discussion on risk-averse, this Chapter, pp. 111-113.

hazard" is introduced into insurance,[1] optimality is no longer valid when it is reduced (moral hazard) by devices such as deductibles (exclusion of a certain amount of expense for coverage) and coinsurance (individuals are required to pay some fraction of each dollar of cost) which influence the usage or demand of medical insurance services.[2] If the relationship between social goods and externalities are close enough, government interference is necessary. Apart of the failure of the market to provide all goods and services, apart of the presence of externalities that necessitate government intervention, the interdependencies of individuals' preferences are "always a theoretical case for collective action if each of the participants derives satisfaction from the contributions of all".[3]

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1. Moral hazard is designed to recognize "that medical insurance, by lowering the marginal cost of care to the individual, may increase usage". Pauly argued that increase usage due to insurance is not "a moral perfidy but a rational economic behavior", Indeed, if "the cost of the individual's excess usage is spread over all other purchases of that insurance, the individual is not prompted to restrain his usage of care". Ibid., p. 535.

2. See Arrow, K.J., "The Economics of Moral Hazard: Further Comment", American Economic Review, 58 (June, 1968), pp. 537-539.

3. Arrow, K.J., "Uncertainty and the Welfare of Medical Care", loc. cit., p. 954.

5.6 Social Goods and Cost-Benefits Analysis

If we accept that a collective effort should be made to prevent deaths and injuries from traffic accidents, safety should be supplied by the public sector, treated and evaluated as a socially desirable good. Traffic safety calls for an increasing role of government action in the highway system. If a collectivity desires to obtain safety it can act through government to provide it for all individuals. The government may choose to influence resource allocations to approve measures encouraging, discouraging or producing certain outputs in a way that safety becomes a socially desirable good. Thus, this rests on the opportunity to improve economic efficiency by a collective action through extra-market devices.

We are told that the problem of efficient allocation of resource have received greater attention from the younger generation of economists.[1] There exists techniques that have been developed to evaluate public investment program by means of which a collectivity decides whether or not to consume a social good. If a certain level of safety is desirable and that investment programs involve certain level of public investments then there exists

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1. Musgrave, R.A., op. cit., p. 798.

economic criteria which show that the benefits of an improved traffic safety associated with a related investment outlays are a desirable aid as indicator to the government in the rational decision process.

Cost-Benefit Analysis is used for social goods to form an appropriate substitute (in the present state of knowledge) for the operation of the market place. The underlying feature of the method is that social goods are approximatively valued by means of prices that the consumer establish when they choose marketable commodities. But for some social goods, estimation of benefits (or costs) is more difficult. What is of interest is the problem of the intangibles which cannot be estimated in any direct fashion. Analysis of intangibles should be taken into account of in any project.[1] For example, we are never certain that all factors affecting traffic accidents and traffic accident losses are known or adequately described. For any government action in traffic safety assessing in monetary terms the meaning of improved

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1. The problem of intangible may have an important bearing on the selection of investment projects. It is generally difficult to attach monetary values to effects such as the saving of human life, but where they have an important bearing in the decision-making, one should try to quantify them as far as possible. Where quantification in reasonnable terms become impossible, a qualitative statement should accompany the analysis.

road safety raises serious difficulties (among others). Apart from the criteria of preference and the rate of discount in the choice of an investment project, probably an important difficulty that one must face is the economic money value of life.

5.7 Cost-Benefit and Criteria for Investment

It is clear today that a substantial proportion of public funds are for human capital. For most private sectors goods and services are produced for sale in the market place, whereas with some forms of public investments that produce social goods - for example, in roads or education both formal and on-the-job, or health services - this may not be the case. As said before, Cost-Benefit analysis is used for such social goods to form a substitute for the operation of market place. Let the possibility of investment of public funds be in road or in the traffic system. Let the program objectives be the prevention of traffic accidents and the reduction of losses from deaths, injury and property damage. If a possible solution exists for these goals one must consider the eligible alternative programs, the constraints and the degree of certainty.

If traffic safety is not for sale through the market place, and if ascerting a certain level of safety is desirable,

by what procedure can the government allocate his expenditures that could be judged as a guide in the determination of optimal output. To optimize in an economic sense, it is most frequently implicitly assumed that the objective is to get the maximum return from a fixed budget or to achieve a fixed level of benefit at a minimum cost. And in most Cost-Benefit studies, simple comparisons of future benefit at some particular point in time from a specific expenditure determine the preference or the ranking of the alternative.

5.8 Net Benefit and the Discounting Method

The measure of the relative desirability of public expenditures is extremly complicated. Yet, decision must be made. Thus the returns from a specific investment associated with the investment costs should be of a great help as indicator to the government in making decisions.

A well known measure that is associated with a particular project in any period of time is the concept of net benefits. Net benefit is defined as the difference between the value of benefits arising in that period and the associated costs that would result from undertaking an investment project. This concept is worthwhile to the investment decision in that the net benefit may be positive or negative.

Like any other investment, public investment generate streams of benefits and costs from the present into a more or less distant future. Since benefits and costs do not all accrue immediately, but over time, the required technique is to translate streams of benefits and costs to a common basis and time period. Usually the benefits occur as a delayed stream which the costs are concentrated at the outset. But what ever the time pattern, it is necessary that the values arising at different dates be ajusted to be comparable at a given period. Consequently, future values must be discounted to the present value. The discounting method takes account of the anticipated net benefits, and despite a certain degree of uncertainty in the setting out of the prospective returns the discounted net benefits is worthwhile for comparison of benefits and costs. The method should be used in the evaluation of investment projects in the public sector.

5.9 Criteria of Preference or Investment Decision Rules

If there is no capital rationing, i.e., there is no predetermined allocation of public funds to particular sector of the economy; if the projects are consistent with the observed constraints, then the necessity of selecting among projects involves rules that will maximize the dis-

counted value of net benefits to each time-stream. Our concern is the study of decision making procedure for accepting or rejecting projects. An investment project is undertaken if it satisfies some rules. Thus, the choice among projects most generally arises in any of the following three equivalent ways.[1]

5.9.1 The first one that normally comes to mind is the ratio of benefit to cost which is maximized (as its reciprocal). Let R_t be the annual receipts and C_t the annual costs for $t = 1, ---, N$. If i is the predetermined rate of interest and N the anticipated life of project, then the simplest form of selecting projects is to pick up the larger ratio of the discounted value of benefits to the discounted value of costs that exceeds unity, or accept all projects for which:

$$(1) \qquad \frac{B}{C} = \frac{\sum_{t=1}^{N} \frac{R_t}{(1+i)^t}}{\sum_{t=1}^{N} \frac{C_t}{(1+i)^t}} > 1$$

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1. Prest, A.R., and R. Turvey, "Cost-Benefit Analysis: A Survey", in Survey of Economic Theory, Vol. III, Resource Allocation, Toronto: Macmillan, 1967, pp. 175-176. Also Henderson, P.D., "Investment Criteria for Public Entreprises", in R. Turvey (ed.), Public Entreprise, Pinguin Book, 1968, pp. 88-96, and Seagraves, T.A., "More on the Social Rate of Discount, Quarterly Journal of Economics, 84 (August, 1970), pp. 434-440.

The main purpose of this criterion is to select among a number of parallel projects rather than justifying any one of them. It is easier to sort out better projects from the more expensive ones. The justification must rest upon the principle of the maximum net benefit.

Given this limitation, comparison of projects on the basis of Benefits-Costs ratios is ambiguous. One difficulty of maximizing the ratio is that it is difficult to "assign convincing dollar values to many of the benefits of public programs".[1] Government often has to proceed with cost-effectiveness analysis. This ratio can be employed for projects (say, better health services, lives saved or injuries avoided from improved traffic safety) where the discounted cost-effect ratios are expressed in different kinds of units.

5.9.2 The Internal Rate of Return (IRR) on an investment. It is defined as the rate of discount for which the present value of discounted net benefits is zero.

$$(2) \qquad \sum_{t=1}^{N} \frac{R_t - C_t}{(1 + r)^t} = 0$$

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1. Seagraves, I.A., op. cit., pp. 431-432.

If there is no capital rationing, the correct course is to undertake all investment programs for which the IRR is greater or equal to the rate of interest, and pick the project that gives the greatest rate of return. This criterion is used in public as well as in private investment projects.

The rule seems unambiguous in that it does not assume predetermined knowledge of the interest rate. But it becomes difficult to solve equation (2) for r when there are technical difficulties associated with the IRR, in particular where there is a stream of investment outlays with time and a stream of estimated receipts. The main problem with the IRR is that it involves the implicit assumption that the flows of receipts as projects mature are reinvested at the solution rate of retunr.[1] If reinvestment is allowed for in this way, the estimation of returns may become a more complicated matter.[2] In this case the IRR rule for evaluating and ranking projects may be unsatisfactory. To that extend, Seagraves argued that if the IRR "which can be earned on money reinvested is known and used as the rate of discount, then present values or benefit-cost ratios will give a better ranking of projects" than will IRR.[3] Another difficulty, especially for public projects of welfare type (health, safety..), is that this criterion does not pay attention to

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1. Ibid., p. 436.

2. Henderson, P.D., op. cit., pp. 121-123.

3. Seagraves, J.A., op. cit., p. 437.

incommensurable units[1] for benefits and costs. For example, for any investment project that aim to improve traffic safety as to reduce traffic death over a period of N years, it is meaningless to use the IRR unless one is willing to put a dollar value on human lives saved.

5.9.3 The Present Discounted Value of an investment is given by the difference between the time streams of anticipated net benefits. It is obtained by subtracting the present value of all the associated costs from the present value of anticipated benefits discounted by an appropriate predetermined rate of interest. The correct course of action is to undertake expenditures for which the present value of net discounted benefits is strictly greater than zero, or

$$(3) \qquad \sum_{t=1}^{N} \frac{R_t}{(1+i)^t} > \sum_{t=1}^{N} \frac{C_t}{(1+i)^t}$$

This rule appears to be clear and informative: costs and benefits have to expressed in the same kind of dollar

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1. Incommensurable is a consequence that cannot readily be translated into a common denominator. If certain benefits are measurable, say in dollar units, "the effects that cannot be measured in money by any objective and generally acceptable methods are incommensurable". See Hitch, C.J., and R.N. McKean, The Economics of Defense in the Nuclear Age, Cambridge, Mass.; Harvard University Press, 1967, p. 182.

units and once the difference is formed the discounted benefit is equivalent to a discounted saving. But still, like the IRR criterion, the present discounted value cannot deal with incommensurable units. In that respect, the existence of incommensurable units should be shown explicitly in the analysis in addition to any rankings provided by the PDV criterion.

It follows from this discussion that no single decision rule is universally best. Each criterion has its particular merits and deficiencies. What is vital is to state what rule is to be used to neasure the relative desirability of public investment (as well as private) and, if necessary, why? In most instances, these three criteria lead to the same ranking of alternatives if the same social rate of discount is to be used.

5.10.1 Choice of the Discounting Rate. The use of an appropriate rate of discount in the economic evaluation of public investment projects is crucial. Its role is to evaluate at a point of time a stream of net benefits that occurs over time. Discounting is particularly important when long-life public projects are involved. Also the choice of an appropriate rate is perhaps the most crucial problem: the higher the rate, the lower the present value of future

benefits of government programs. A too low rate may lead to a "waste of resource on a project yielding less satisfaction to the community than would alternative uses", and a too high rate of discount "may leave resources underdevelopped".[1]

What is the appropriate rate of discount that should be employed, for example, in traffic safety improvement which save human life? Since some of the benefits of such program certainly accrue later after the investment outlays, the choice of the discount rate may have a great influence on the present value of human life saved from such program. Must the selection only be done by the government? Is it lower than the discounting rate for private investment? If so, how much lower? It seems therefore that there is no agreed way of selecting it and that there is an open discussion on the arguments and assumptions that centered around whether the capital market is perfect or the existence of divergence between the discounting rates in the public and the private sectors.[2]

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1. Marshall, H., "Rational Choice in Water Resources Planning", in S.C. Smith and E.N. Castle(eds.), Economics and Public Policy in Water Resource Development, Ames, Iowa: Iowa State University Press, 1966, p. 407.

2. See espescially Musgrave, R.A., op. cit., pp. 801-803; Prest, A.R., and R. Turvey, op. cit., pp. 162-172; Henderson, P.D., op. cit., pp. 96-135; Arrow, K.J., "Discounting and Public Investment Criteris", in A.V. Kneese and S.C. Smith (eds.), Water Research, Baltimore Maryland: The John Hopkings Press, 1966, pp. 13-28; Eckstein, O., Water Resource Development: Economics of Project Evaluation, Cambridge: Havard University Press, 1965, pp. 43-104; and Seagraves, T.A., op. cit., pp. 430-440.

5.10.2 Government's borrowing rate on long-term securities is practically used in cost-benefit analysis for approximating the rate of interest. It has been argued that this rate exists and is known precisely.[1] Does the rate measure the social cost of public funds employed in projects. Eckstein has challenged this practice. It is false to believe that the way government raises funds to finance projects is done by voluntary bond sales to the private sector. There is no evidence that the social cost of funds is the rate at which the voluntary lenders are willing to lend money to the government. It rather depends upon the rate of interest reflecting the value of money to those who pay the taxes.[2]

Other have argued that the government can raise funds at a lower rate than most private firms do. Thus the appropriate discounting rate for public projects would be below the private rate of discount. Even if the government undertake investments that are riskier, the fact that it is "credit-worthy" does not allow it to undertake all public programs at a low rate of discount. Many noneconomic returns are expected from public programs. These are not taken into account by the private sector (for the same projects).

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1. Henderson, P.D., op. cit., p. 97.

2. Eckstein, O., op. cit., p. 96.

But this does not mean a lower rate of borrowing.[1] The result would be an overestimation of benefits (say money value of life saved) of long-life projects and may lead to a justification of public programs of little economic value.

5.10.3 Social Opportunity Cost. Despite the popularity of the government borrowing rate as an easily applicable measure of government financing cost and as a riskless rate of interest, the rate must reflect the opportunity cost of capital.[2] As an appropriate measure of the social cost of raising public funds, the opportunity cost is defined in terms of opportunities foregone in the private sector. Thus the social cost raised by foregone investment is equal to the foregone rate of returns on private investments. Under perfect competition, the social opportunity cost can be expressed as an equivalent rate of return for discounting. The proper rate would be the one which set the present value of anticipated net benefits of marginal projects equal to zero. In other words, the social opportunity cost rate is represented by the market rate of interest equal to the

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1. Weisbrod, B.A., "Preventing High School Dropouts", "Comments", by Fritz Machlup, in Robert Dorfman (ed.), Measuring Benefits of Government Investment, Washington, D.C.,: The Brookings Institution, 1965, pp. 156-157.

2. Prest, A.R., and R. Turvey, op. cit., pp. 170-171.

internal rate of returns on private investments (and government non-social goods).[1]

It is very important to trace out the sources of financing government projects. The social opportunity cost is defined by Krutilla and Eckstein in terms of opportunities foregone either because of taxing consumption or taxing investments.[2] Ultimately it depends upon which group in private sectors lend the funds. But the social opportunity-cost is hardly measured by a single rate of return since it depends on the source of the particular funds.[3] In each case, they arrived at a weighted average "rate of interest (or taxes shares) analogous to the internal rates of return for evaluating the present value of net benefits of a public investment project. If more government investment programs are met by having less consumption, this pose the problem of which alternative is marginally desirable. This definition is surely open to criticism in that it "attaches greater

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1. G.L. Reuber and R.J. Wonnacott have suggested that a rate of 5% may be regarded close to the opportunity cost of capital, and used in discounting the benefits and costs of those investment projects evaluated from a social point of view in Canada. See Rueber, G.L., and R.J. Wonnacott, "The Cost of Capital in Canada", Resources for the Future, Inc. Publication, Washington, D.C., 1961.

2. Krutilla, J.V., and O. Eckstein, Multiple Purpose River Basin Development, Baltimore: The John Hopkins Press, 1958, pp. 78-85.

3. Feldstein, M.S., "The Social Time Preference Discount Rate in Cost-Benefit Analysis", Economic Journal, 74 (June, 1964), p. 361.

weight to private judgement of individuals than to the judgement of the society".[1] And a subjective value judgement is needed on this point.

5.10.4 Social Rate of Discount (Social Time Preference). The rate of discount is used to balance the return of an investment and the ralative reluctance of society to forego current values for future consumption. The social rate of Discount (SRD) is the opportunity cost of deferred consumption that reflect the society's judgement about the relative evaluation that government (or collectivity) feels that it ought (or is believed) to assign to consumption at different points in time.[2] Any public investment decisions must be made as to reflect the fact that present consumption is preferred to future. Thus the SRD has a normative significance for public investment programs in that it must "reflect public policy and social ethic, as well as judgement about future economic conditions".[3]

We are thus left with a wide range of discount rate to select. But the SRD should not be confused with other

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1. Eckstein, O., op. cit., pp. 97-98.

2. Henderson, P.D., op. cit., p. 98; also Feldstein, M.S., op. cit., p. 361.

3. Ibid., p. 362.

interest rates. One could choose one of the following rate under appropriate circumstances: the government borrowing rate; the private borrowing rate; the opportunity cost of transferred resources; the internal rate of return on marginal projects. But all these rates are not necessarily equal to the social rate of discount used for alternative projects. These inequalitites are generated mostly by the imperfections in the capital market.

Discussion on this problem starts with the following question asked by Prest and Turvey: under perfect capital market, does the predetermined market rate of interest suffice for community investment decisions?[1] The going rate of interest may not be always appropriate. For a given situation, the private market and the collective time preferences may not coincide. Thus, this open the question of the connection between the market rates of interest and the social time preference. In general, public decision is done on the basis of the SRD rather than the private rate of discount (PRD) because individuals may discount future benefits at a higher rate. Generally the private rates of discount may differ with respect to public investment decision.[2]

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1. Prest, A.R., and R. Turvey, op. cit., p. 169.

2. Henderson, P.D., op. cit., p. 98.

Let the capital market be perfect in a world of certainty and, thus, all rates of return equalized. In this setting the market rate of interest equalizes both the SRD and the PRD in equilibrium. It is the same principle for public investment that is undertaken if the sum of the present value and cost is zero when using the PRD. Then no conflict arise between the social and private benefit (and cost).[1] In such a situation, the PRD and the SRD are equalized if the STP of one individual is alike for every other individual. Then the market rate of interest have some normative significance for public investment decisions. This holds, according to Marglin, only if the individuals in the community have similar preferences and incomes.[2]

Both Marglin and Feldstein have rejected the notion that the perfect market rate of interest "need have any normative significance in the planning of collective investment".[3] If each individual is willing to make greater sacrifices for future generation, if this willingness is shared collectively, and if this foregone consumption is not reflected in the market rate of interest, this rate would therefore "provide no guidance as to how people would

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1. Musgrave, R.A., op. cit., p. 801; also Arrow, K.J., op. cit., pp. 13-14.

2. Marglin, S.A., "The Social Rate of Discount and the Optimal Rate of Investment", Quarterly Journal of Economics, 77 (February, 1963), pp. 101-105.

3. Ibid., p. 111.

wish the government to act".[1]

Both have rejected the market oriented rate of interest (Pigou's defective telescopic faculty) in favor of a political determination of the STP rate lower than the market rate of interest.[2] Market imperfections, such as inequality of income and varying preferences and such that in equilibrium, it is reasonable to assume that SRD is lower that the PRD. The answer to this is given by the fact that government produce social goods that are not taken into account by the private sector. If present public investment in the production of social goods yields benefits only at a later future date and if social goods are consumed simultaneously by all the individuals, then the individual's satisfaction depends directly of the consumption pattern of the collectivity.

5.10.5 The mixed STP with SOC rates of Public Investment and the "Second Best" Approach. Felstein has argued that no single discounting rate has yet be found that evaluate both the time preferences and the rates of return. He further argued that many of today research in mainly concerned with

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1. Henderson, P.D., op. cit., p. 97.

2. Feldstein, M.S., op. cit., pp. 364-367 and Marglin, S.A., op. cit., pp. 96-97; also Prest, A.R., and R. Turvey, op. cit., pp. 169-170.

a single rate (in the cost-benefit context) with value judgement for the public investment programs.[1] If this statement is correct, it is clear that the time stream has no correct solution in the present state of knowledge.

We know from the above discussion that the discount rate and the opportunity cost (taken as a rate of return) are two different concepts and that they are generally not equalized. We are told for most cost-benefit analysis that the divergence between the SRD and IRR is taken as given.[2] Both rates are nevertheless required in the evaluation of the net benefits from public expenditures. They are important in that the latter evaluates the stream of benefits from alternative public projects. It is a measure of the opportunity cost of transferred funds. The present value of stream of benefits of the opportunity cost is given by the SRD, measuring the degree of preference for present over the future consumption.

Some authors have evaluated the value of public funds by using a "second best" procedure.[3] According to this

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1. Feldstein,M.S., op. cit., p. 361.

2. Musgrave, R.A., op. cit., p. 301.

3. See especially Marglin, S.A., op. cit., pp. 276-278, and Musgrave, R.A., op. cit., pp. 801-802.

approach, public projects are undertaken if it avoid displacing better opportunities in the private sector. Applying a common SRD to all alternatives, public investment projects are undertaken if the present value of all the net benefits exceed the present value of consumption foregone because private investment is not made.[1] This rule however is facing some difficulties. One of the problems is one of choosing between say two alternatives. It the two investments have the same returns, we retain the one for which the present value of net benefits to society is the greatest.[2] Thus, question often asked is what is the rule that make one deciding whether a private investment offers better opportunities than a project using public funds. Still the problem of choosing the relevant rate of discount for comparing opportunities offered by private and public investments. Eckstein has proposed a compromise to that matter: "let the government use a relatively low rate of interest for the design and evaluation of projects, but let projects be considered justified only if the benefits-costs ratio is well in excess of 1,0".[3]

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1. Musgrave, R.A., op. cit., p. 301.
2. Marglin, S.A., op. cit., pp. 276-278.
3. Eckstein, O., op. cit., p. 101.

5.11 The Treatment of Risk and Uncertainty

Risk and uncertainty were absent from the above discussion. But for most decision that "often depend on events that are beyond human control",[1] risk and uncertainty are factors that should be accounted for in the measurement of costs and returns associated with an investment project.[2] Related to public investment projects, the treatment of uncertainty is controversial. How risk and uncertainty should be handled in public investment decision and what should the appropriate rate of discount be in the evaluation of the present value of net benefits? Should collective decisions be weighted in the same way as private decision? Controversial arguments arise on whether the

(i) appropriate rate of discount for public investment should be the same as would be employed in the private sector for comparable projects, and that rate of discount

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1. Malivaud, E., "Risk-Taking and Resources Allocation", in J. Margolis and H. Guitton (eds.), Public Economics: An Analysis of Public Production and Consumption and Their Relations to The Private Sectors, Toronto: Macmillan Co., 1969, p. 222.

2. To avoid any confusion we define risk and uncertainty according to the economic theory. Risk is a situation in which outcomes (or events) are uncertain (or variable) but they obey of known probabilities. We speak of uncertainty if nothing is known of such probabilities. It should be noted however that this distinction is meaningless for the Baysian statisticians.

be risky rate, or

(ii) that the government takes advantage of his taxation power and then, is completely ignorant of uncertainty and indifferent to risk? These two lines of arguments have been presented by J. Hirshleifer[1] and, more recently by K.J. Arrow and R.C. Lind.[2]

5.11.1 Market Behavior and Individual Preferences under Uncertainty

The Arrow-Debreu "sate-preference" approach is the common procedure that has been advocated to analyse market behavior under uncertainty.[3]

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1. Hirshleifer, J., "Investment Decision Under Uncertainty: Application of the State-Preference Approach", Quarterly Journal of Economics, 80 (May, 1966), pp. 252-277.

2. Arrow, K.J., and R.C. Lind, "Uncertainty and the Evaluation of Public Investment Decisions", American Economic Review, 60 (June, 1970), pp. 364-378.

3. Hirshleifer defined "state-preference" as an approach which resolves the assets into distributions of dated contigent claims to income defined over the set of all possible "states of world". The problem of investment decision under uncertainty can also be examined by the "mean and standard deviation" approach which reduces the assets traded in the market to underlying object of choice in the form of mean-return and variability-of-return measures, which, it is alleged, enter into investor's preference function. For a complete statement of these alternative approaches, see Hirshleifer, J., op. cit., pp. 252-268 and more particularly Hirshleifer, J., Investment, Interest and Capital, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970, Chapter 8, 9 and 10.

The standard model runs as follow:

For simplicity we introduce a single commodity and a single individual (or, all individuals are alike), individual owns, before trading. Let each individual owning, before they trade, the quantity $\bar{\bar{X}}_{he}$ of the commodity h of given specifications under the condition that the "state" e occurs. We further suppose that each individual has a subjective probability q_e of "state" e, and p_e be the market price for transactions in the "contigent good" (h, e). Further suppose that

$$(4) \qquad \mathcal{U}(X) = \sum_{e=1}^{n} q_e \, U(X_e)$$

is the utility function of the "representative" individual. If each individual is a von Neuman-Morgestern expected utility maximizer with the assumption of risk-averse (diminishing marginal utility),[1] then, each individual chooses claims X_s so as to maximize (4) subject to

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1. Risk aversion is expressed by $\mathcal{U}(\bar{X}) \geq \mathcal{U}(X)$; or equivalently by

$$U\left(\sum_{e=1}^{n} q_e \, X_e\right) \geq \sum_{e=1}^{n} q_e \, U(X_e)$$

See Malinvand, E., op. cit., p. 227.

$$(5) \qquad \sum_{e=1}^{n} p_e \, (X_e - \bar{X}_e) = 0$$

and

$$(6) \qquad X_e \geq 0$$

where $U'(\,) > 0$ and $U''(\,) < 0$. By the Lagrangian technique, the condition for equilibrium states that $q_e \, U \, (X_e) = \lambda p_e$. And for any two different states e and d, it follow that

$$(7) \qquad \frac{p_e}{p_d} = \frac{q_e \, U'(X_e)}{q_d \, U'(X_d)}$$

In equilibrium, the price of claim p_e indicates the terms on which a given individual is willing to trade certain income for risky returns.[1] Thus if the individuals are expected utility maximizer, they will value an asset with uncertain outcomes in such a way that the present value of returns be properly adjusted for risk. Therefore, the appropriate rate of discount is defined by[2]

$$(8) \qquad \sum_{e=1}^{n} p_e = \sum_{e=1}^{n} \frac{1}{1 + r_e}$$

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1. Brainard, W., and F.T. Dolbear, "Social Risk and Financial Markets", American Economic Review, Papers and Proceedings, 61 (May, 1971), pp. 360-370.

2. Arrow, K.J., and R.C. Lind, op. cit., p. 368.

5.11.2 Public Investment Under Uncertainty

Given the above observations for the individual, Arrow and Lind have suggested, in the lines of Hirshleifer, two conflicting procedures to deal with the problem of public investment decision under uncertain returns.[1]

The first position deal with the view that the government should value projects in the same way as private investment. Therefore, a question arise: should the government choice exhibit risk-aversion?

Let ℓ_e be the random outcome from a public investment under perfect capital market. If risk is discounted in the same way as it is in the private sector, then, a public project should be introduced if

$$\sum_{e=1}^{n} p_e \ell_e > 0$$

or, expressed differently

$$\sum_{e=1}^{n} \frac{\ell_e}{1 + r_e} > 0 \qquad (9)$$

Under the assumption that public investment is independant of rational income that is, "the net returns from an invest-

1. Ibid., pp. 368-376.

ment be independent of the returns from previous investments"[1], equation (9) implies that the government should behave as an "expected value decision maker".[2]

Hirshleifer argued that any departure from the perfect market equilibrium rate of interest which is generated by "the marginal time preferences of consumers and the marginal time productivity of resources", in evaluating public investment projects may lead to inefficient results.[3] But to take account of risk in an imperfect world, risk should be discounted in the same way as it is for public investment. Thus, the appropriate discount rate should be that "market rate implicit in the valuation of private assets whose returns are comparable to the public investment in question".[4] If risk is not taken into account by government the discounting rate would be lower than the one used in the private sector and, accordingly, yielding inefficient results in that public investment would be overestimated by displacing

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1. Ibid., p. 369.

2. Ibid., p. 366.

3. Hirshleifer, J., "Investment Decision under Uncertainty", op. cit., p. 269.

4. Ibid., pp. 276-277.

private projects yielding higher returns.[1]

The second procedure to evaluate public investment under uncertainty is to use a discount rate that should be independent of consideration of risk. This position has been favoured by Arrow and Lind. They argued that when risk, as well as benefits and costs, are associated with public investment and if it is socially borne then the expected net value of any project should be maximized without any deduction from the total cost of risk.[2]

The disagreement with the first procedure follows from the idea that the independence assumption does not hold since insurance markets for risk do not exist for every contingent commodity and that individuals tend to overestimate their expected value of returns.[3] Accordingly, government should not display risk-aversion in its behavior

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1. Ibid., pp. 269-270. This problem have brought Arrow and Lind to discuss the Hirshleifer's recommendations that government should be a supplier of insurance and that private investment be subsidized. They concluded in one case of "the inherent difficulty in establishing certain markets for insurance brings about a sub-optimal allocation of resources and, in the other case, that subsidies to encourage more private investments will encourage investments which are inefficient when the costs of risk are considered", Ibid., pp. 374-375.

2. Arrow, K.J., and R.C. Lind, op. cit., pp. 366-367 and 369-373.

3. Ibid., p. 369.

and take advantage of its taxation power in undertaking investment projects that are profitable. Thus, "government should ignore uncertainty and behave as if indifferent to risk".[1] If the argument that risk-aversion is not a social but a private cost, the appropriate procedure to compute the expected value of net returns is to use a discount rate that is riskless.[2]

The choice of a riskless rate of discount arises, we are told, because of the "risk-spreading aspect" of public investment. In an idealized public investment, government is assumed to "distribute the risk associated with any investment among a large number of people".[3] Arrow and Lind have demonstrated that for a public investment with uncertain outcome, the public costs of risk-bearing should depend "both upon which individuals receive the benefits and pay the costs and upon how large is each individual's share of these benefits and costs".[4] Given that the government takes advantage of

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1. Ibid., p. 364.

2. As an example, suppose that a public project yields a certain return of 5% plus an expected return of 7% properly adjusted for risk. Then the appropriate riskless rate that the government should use is 5%. Perhaps, the pure interest rate plus risk premium (7%) is also an appropriate discount rate for public investment projects.

3. Ibid., p. 366.

4. Ibid., pp. 370-374.

its taxation power in undertaking a public investment, they concluded that "all benefits and costs accrued to the government and were distributed among the taxpayers. In this sense, all uncertainty was borne collectively".[1]

5.12 Conclusion

The outcome of the above whole discussion on the rate of discount has not given us a precise answer on what should the rate of discount be for government policy recommendation? Yet, a decision has to be taken on a rate of discount to evaluate public investment projects. Should it be lower or higher with respect to the two above contreversial position?

Most authors, especially Hirshleifer, Arrow and Lind have disregarded the collective time preference rate of interest for use in public investment decisions under uncertainty.[2] This rate is thought to be lower than the long-term rate of interest and its use might involve sacrifice of present consumption. Indeed, choosing such a rate might lead to speculative and uncertain matter. Arguments in favor of a higher social rate of discount in public invest-

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1. Ibid., pp. 376-377.

2. Hirshleifer, J., op. cit., pp. 268-269, Arrow, K.J., and Lind, op. cit., p. 365.

ments dealing with projects involving risks would then be justified on the following ground: markets are so imperfect that the observed "pure rate" of discount is inadequate that is it reveals "no relevant information about the time and risk preference of individuals".[1]

If we accept that public investment projects should be valued on the basis of the individual willingness to pay and that the costs and benefits of a given project accrued directly to individuals, should the government choose the appropriate rate of discount as would these individuals? The answer to that question is not so easy. It has been argued that for different streams of benefits and costs, the uncertain outcomes should be discounted at interest rates "ranging form the certainty rate for benefits and costs accruing to the government and using higher rates that reflect discounting for risk for returns accruing directly to individuals".[2] This position favoured therefore, a particular social rate of discount lying between extreme values and the choice of a higher rate with the existing long-term of interest as the minimum.

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1. Ibid., p. 365.

2. Ibid., p. 377.

In following this line of arguments, one must be careful however in choosing a discounting rate with respect to uncertainty that values public investments for say life-saving program. If we let the present value of such a program be computed on the basis of individual willingness to pay, to avoid or reduce traffic death and injury, expenditure for such programs might be underestimated in that it might reveal little about the value of human life saved by this safety program. The markets being so imperfect and individuals generally ignoring the external social costs of their individual decisions, it would not be appropriate to rely on the willingness to pay as primacy criterion to solve for the social rate of discount. In a comment of T.C. Schelling's Paper, G. Fromm concluded that such a criterion is very complex and relatively imprecise. This is not to say "that the amount individuals are willing to pay for mortality reduction should be ignored in the formulation of such programs. It is merely to indicate that, at best, willingness to pay provides a guide to the minimum and to the maximum desired normative expenditures".[1]

If there exists a general consensus that the number of automobile accident fatalities are above an acceptable level,

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1. Schelling, J.C., "The Life you Save May be Your Own", in S.B. Chase, Jr. (ed.), Problem in Public Expenditure Analysis, Washington, D.C.; The Brookings Institution, 1968, p. 174.

improvement of traffic safety is needed. However, the problem of allocating resources among a variety of possible safety programs demands that public decisions be based upon consideration of relevant evidence. The selection among the courses of action is not an easy task. Decision-makers need to be assisted by some technique. Costs-benefits analysis provide such technique in the rational determination of the allocation of resources to traffic safety. As a set of procedures, costs-benefits analysis organize all the explicit facts in ways helpful to the decision-makers to select among alternatives the best (or improved) solutions to traffic safety problems.

When the formulation of the objectives, of the alternatives, and the identification of the constraints have been done, the formulation of the criteria of preference used to rank alternatives and to indicate their relative worth present a difficult problem; especially when intangibles and incommensurables are involved. Other criteria may be needed to implement the technique. Placing a capital value to human beings makes certain investment decisions criteria possible. For example, an investment decision might involve choosing between a public expenditure in traffic safety to save human life and, an investment outlay that yield income.

Such decision requires assigning a monetary value to human life. The use of human capital approach to estimate the losses to society from traffic accidents fatalities may be, then, useful for an investment criteria.

Chapter 6. A HUMAN CAPITAL APPROACH TO VALUE HUMAN BEINGS: A CASE STUDY IN THE AUTOMOBILE ACCIDENTS

6.1 Introduction

We have been told that the value of human life ought to be considered, at least partially, without regard to whether the person who might die is a producer or not; and that this value should in fact result from a collective decision concerning the expenses that a community agrees to spend, in order to save one of its members.[1]

Today public opinion is increasingly concerned over the magnitude of the traffic accident toll of death, injury and property damage. In 1961, 3,590 persons were killed in Canada and 71,419 injured from traffic accidents amounting to a total property damage of 84,7 million dollars.[2] A fundamental value judgement is that traffic safety is a significant, tenacious and growing social problem, and has become a subject of increasing national concern.

Pressures to develop and apply remedial measures are intensified: "Every day, decisions are taken. A crossroad is laid out, but a sharp turn remains".[3] But the traffic

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1. Thedie J., and C. Abraham, "Economic Aspects of Road Accidents", Traffic Engineering and Control, 2 (Feb. 1961), p.590.

2. Canada, Dominion Bureau of Statistics, Motor Vehicle Traffic Accident 1961, (Cat., No. 53-206) Ottawa: Queen,s Printer, 1962.

3. Thedie J. and C. Abraham, op.cit., p.590.

safety problem has many dimensions. There are many human and economic factors to be considered. From such complexity, decisions depend upon informations used to describe and quantify the problems, isolate accident causes or associations, and evaluate the improvements.

One must acknowledge that the principle of better or improved road safety in terms of accident reduction seems evident. Motivated by humanitarian considerations, traffic safety is certainly a positive goal. Underlying that principle is that traffic safety is "purchasable" in the sense that there exists technical and engeneering knowledge that could be applied through public funds to prevent much of the current deaths and injuries arising from automobile accidents.

The problem of road safety is recognized when accidents cause loss of life and property. Thus if the toll of death, injury and property damage is continuously increasing each year, why does society allow that to continue? Why does the society refrain from fighting it with all the knowledge and tools at its command? Why should even one person become a victim of preventable death or injury?

Apparently, the answer to these questions are not self-evident. If society is economically concerned with investment programs that affect statistical automobile accident fatalities, the economic losses from such events are possible of estimations. However, the evaluation of a given individual death requires more than an economic evaluation: it requires attention of some incommensurable feelings, surrounded by some individuals' behavior viewing life as a unique event and death as an awesome event.[1]

When concerned with life and death, individuals are all consumers: "we nearly all want our lives extended and are probably willing to pay for it".[2] This observation brings some kind of incompatibility between individuals' consumptions and personal feelings. Individuals and/or society carry then a series of trade-offs. Society may be more concerned by the death of some identified groups and is ready to make some reasonable financial efforts (e.g. to recover dead bodies from a collapsed coal mine shaft or from an airplane crash) rather than devoting the available resources to prevent death events. However, society faces many investment alternatives that prevent statistical death to occur and public investment should be rationalized in a way to achieve economic efficiency.

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1. Schelling, T.C., op.cit., p. 127.

2. Ibid., p. 129.

The purpose of this chapter is not to identify the weaknesses and to suggest remedy in the present system of highway that could reduce the losses arising from accidental death, injury and property damage. The present analysis will be mostly concerned with the capital value of man that could serve as an indicator to the policy maker in elaborating traffic safety measures.

This chapter will briefly review how some writers have used in the past the concept of human capital to value human life and will then present the formula used to estimate man,s gross contribution to production. These estimates would then be used in evaluating the economic losses to society as a result of automobile accidents.

6.2 Development of a Conceptual Measure of Human Capital

Through its long development the concept of human capital has not always been incorporated within the physical capital "framework". It is only recently that the concept of capital as applied to human beings has become fashionable.

Conceptually, the procedures of estimating such money or capital values of either individual or group of individuals' assets have been developed in two ways:

(1) the costs-of-production concept, measuring the total cost of developing a productive labor force, or to put it another way, all costs incurred in human capital formation, by an appropriate estimate of direct and indirect costs of producing a particular unit of human capital. Essentially man is viewed as a capital asset that yields future return, and all the costs are included in the investment outlays;

(2) the capitalized-earnings concept of a capital stock measure of the present monetary value of individuals' future earnings stream.[1]

These two concepts of a system of measurement of human assets centered around the two main determinants of physical capital, that is the gross and net concepts of capital theory. No attempt is made here either to discuss in details both the cost-of-production and the capitalized-earnings concepts or to analyze the economists' contribution toward the development of effective procedures for the evaluation of human capital.[2]

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1. Kiker, B.F., op. cit., pp. 49-50.

2. For the readers who might be interested in a summary and appraisal of the methods of evaluating human capital which have been developped in the past and of the various uses to which the concept of human capital has been put, see especially Kiker, B.F., Human Capital in Retrospect, Columbia, S.C.; College of Business Administration, University of South Carolina, 1968, 142 pp.

The initial outlines for estimating the money (capital) value of man were set down by Sir William Petty (1691). Essentially a capitalized-gross-earnings procedure, he has determined an average per-capita value of individual by estimating the value of the whole population's total product. Petty has used the notion of human capital to demonstrate the power of the Nation (England), the economic effects of migration and labor mobility, and to determine the money value of human life destroyed in war and losses resulting from death.

The economic value of human beings can also be measured by the value of his future earnings net of his consumption. It includes the contribution of an individual as a net producer. The first rigourous technique to value human being was instituted by William Farr (1853). Farr's method is to compute the economic value of human life by discounting the value of future earnings net of consumption, allowance being made for deaths in accordance with a life table. And like Petty before him, he applied his estimates of human values to problems of public policy, including tax policies, as well as health programs.[1]

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1. For a summary of Farr's method see Kiker, B.F., op. cit., pp. 5-11.

Farr's basic procedure is still a fundamental method used by present-day writers interested in estimating the capital value of man and it may be contended as a fundamental method used by present-day writers interested in estimating the capital value of man and it may be contended as a fundamental approach for human capital evaluation of man. Among them, T. Wittstein (1867) oriented his interest of evaluating human life at a given age towards compensation that should be given to conscripted life in time of war.[1] But L.I. Dublin and A.J. Lotka have contributed the major work on the methods of evaluating human capital.[2] They defined the capital value of man as the present and discounted value of future earning power of active man reduced by the costs of birth, upbringing and maintenance during his working life and retirement. They also believed that the money value of man would be useful for varied purposes:

(1) in solving the insurance problems;

(2) in estimating the economic costs of life-conservation;

(3) and in estimating the compensation for personal injury and death in courts.[3]

A number of recent writers, following Farr, and Dublin and Lotka have used the capitalized-earning approach to value human capital to demonstrate the economic profitability

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1. Ibid., pp. 11-15.

2. DUBLIN, L.I and A.J. LOTKA, The Money Value of a Man, New York: Ronald Press Co., 1930.

3. KIKER, B.F., op. cit., pp. 19-24.

of health services and death-injury prevention. Interested in measuring the economic benefits of suppressing or decreasing the incidence of specific disease or illness, Burton A. Weisbrod utilized the capitalized-net-earnings approach to value human capital.[1] Objecting to the "net" concept when dealing with human capital value of an individual to society, Rashi Fein was concerned with the value of human beings unemployed because of mental illness.[2] Other writers, such as D.J. Reynolds[3], J. Thédie and C. Abraham[4] and Garry Fromm[5] have utilized the "net" approach to value human capital. Their main interest was to assess the monetary losses in human capital resulting from traffic accident deaths and injuries.

The outcome of this discussion is that human capital values have been conceptually estimated by both the costs-of-production and the capitalized-earnings approaches. As seen in chapter 4, the problem of investment consumption dichotomy and the difficulties of treating depreciation and maintenance cost doubt on the value of the costs-of-production concept, and is less useful than the capitalized-earnings

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1. Weisbrod, B.A. The Economics of Public Health, Philadelphia: University of Pennsylvania Press, 1961.

2. Fein, P., Economic of Mental Illness, New York: Basic Book Inc., 1958.

3. Reynolds, D.J., "The Cost of Road Accidents", Journal of the Royal Statistical Society, 119, (1956), pp. 393-408.

4. Thedie, J. and C. Abraham, op. cit., pp. 589-595.

5. Fromm, G., "Civil Aviation Expenditures", R. Dorfman (ed.), Measuring Benefits of Government Investment, Washington D.C.: The Brookings Institution, 1965, pp. 173-237.

approach. The latter concept is mostly adopted today by economists. This approach implicitly assumes no depreciation until a man is retired from the active life.

The capitalized-earnings approach is frequently used to estimate the value of life saving. Since it treats individuals as capital, the capitalized-earnings concept is a good starting point to estimate the monetary losses resulting from traffic accident deaths and injuries as it represents an explicit measure which might give direction to common sense and rationality to improve life-saving decisions.

6.3 Measurement of Economic Losses

It is widely accepted that the accident costs can be subdivided between the economic costs to society and the incommensurable costs. The former represent the losses of output of goods and services due to death, personal injury and property damage. The latter loss represents psychic losses due to such things as pain, fear and suffering to the victims due to the death or personal injury as well as to society. These psychic losses are very real but impossible to measure. Often they are assigned zero value by default.

The largest loss of persons who are seriously injured or killed in automobile accidents is income loss. This loss may accrue to the individual himself, to his family, or to society. It is a difficult loss to measure accurately because if involves predictions of future occupation, education level, employment status (i.e. whether or not employed), consumption costs, and working life as well as the choice of appropriate rate of discount.[1]

6.3.1 The Model

The present monetary (or capital) value of an individual at any given age may be defined as his discounted expected future earnings,[2] or

$$L_a = \sum_{n=a}^{\infty} \frac{Y_n \, E_a^n \, P_a^n}{(1+r)^{n-a}}$$

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1. The individual's occupation and education level at the time of the accident is taken as found and it is assumed that there would have been no change in the absence of the accident. See in particular, Holmes, R.A., "On The Economic Welfare of Victims of Automobile Accidents", American Economic Review, 60 (March, 1970), pp. 143-152.

2. Weisbrod, B.A., The Economic of Public Health, loc. cit., pp. 48-49 and p. 61, Weisbrod, B.A., "The Valuation of Human Capital", JPE, 69, (October, 1961), p. 427; Weisbrod, R.A., "An Expected-Income Measured of Economic Welfare, JPE, 70, (August, 1962), p. 355; and Carlson, J.W., Valuation of Life Saving, (Unpublished Ph.D. Thesis), Cambridge, Mass: Havard University, 1963. p. 50. See also Mishan, E.J., "Evaluation of Life and Limb: A Theoretical Approach", Journal of Political Economy, 79, (July/August, 1971), pp. 687-705.

where Y_n is the value of an individual's total gross productivity at age n;[1]

E_a^n is the expected future probability of a person at age a of being employed at age n;

P_a^n is the expected probability of an individual being alive from age a to age n;

r is the appropriate social rate of discount.

This formula accounts for a "gross" human capital approach of calculating the capital (or money) value of human beings[2] and, therefore the economic loss to society from traffic accident deaths and injuries.

6.3.2 Discussion of the Model's Components: Shortcomings and Limitations

(Y_n) Man's gross contribution to production. The earnings estimates of the people providing market services (wages and salaries and net income of the self-employed) are usually accepted as a reasonably appropriate measure of man's contribution to market output. Thus it is relatively easy to calculate the losses of output of individuals from traffic fatalities probabilities, since

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1. Are excluded from gross earnings any yields from an individual's ownership of his nonhuman capital assets.

2. If we substract the value of an individual's consumption expenditures at age n, this formula will account then for a "net" human capital approach to evaluate human beings.

under perfect competition these losses are approximately equal to the discounted wages. The discounted values of individuals will be computed as of the year of age in which earnings ordinarily begin.

TABLE 1

Earnings of Wage Earners by Age Group and Sex, Canada 1961. [1]

Age Group	Median Earnings ($)	
	Males	Females
15 - 19	1142	1150
20 - 24	2542	2007
25 - 34	3845	2206
35 - 44	4366	2140
45 - 54	4274	2240
55 - 65	3897	2180
65 and over	2890	1588
All ages	3679	1995

Table 1 represents the statistical earnings figures. They represent median earnings of employed persons according to age group and sex and are used to estimate the capital value of an average workman. The use of cross-section data

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1. Sources: Canada Dominion Bureau of Statistics; Earning of Wages - Earners by Marital Status and Age, 1961, Cat. No. 94-536), Table 15. Averages for wages and salaries earned; for the total labor force the median represents median earnings from all employment either as an employee or a self-employed capacity.

on earnings leave the value of human capital to be computed under static age-group conditions. Dynamic changes and the many distortions found in imperfect markets make it quite difficult to account for data on prospective earnings. No one is prevented, however, from making predictions in these variables. Such changes can only increase the capital value of individuals (increase in the rate of pay corresponding to long-term productivity growth of the economy, falling mortality rate...). However, most estimates of human capital values have been presented with downward bias and therefore, these values do not reflect perfect marginal productivity of labor. In estimating human capital values, another difficulty should be mentioned such as the lack of uniformity in income prospects between different groups of people by occupation and education level, by age and sex.

Since most women provide non-market household services, it is necessary to evaluate these for a complete measure of loss from fatalities. Many economists considered, however, that the exclusion of housewives' services is justified because of the statistical difficulties of measuring, in the form of non-market productivity, the contribution of housewives to the national income. But the difficulties of evaluating their services does not justify an assumption that the services are valueless.

The question, then, is how to measure the value of non-market services. Two methods are generally proposed:

(1) the opportunity cost of being a housewife. This method entails elaborate computations and will not be used for our purpose.

(2) The second method is concerned with the replacement cost of a housewife. The death of a housewife usually created a demand for household services involving a displacement of another woman from some other productive services. The proper evaluation of the housewife is then according to the cost of housekeeping-help, taking into account the size of the household to be cared for. This method has been well presented by Weisbrod. He argued that "although the housewife performs her duties without direct remuneration, the performance of comparable duties by housekeepers are purchasable in the market".[1]

(C_n) Allowance for Consumption. Diversity of opinion dominates regarding the treatment of consumption. It presents a most challenging problem regarding the determination of"the magnitude of personal consumption which

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1. Weisbrod, B.A., The Economics of Public Health, loc. cit., pp. 114-119.

ought to be attributed to a person over each year of his or her lifetime".[1] Economists agree that individuals and families should deduct consumption in their calculation of human capital value. Society is then defined as "to exclude the individual whose life is being valued, then his contribution to society consists only of any excess of what he adds to total output over that he substracts from it, his consumption; and his economic worth is the present value of his net future earnings".[2] The "net" formula, then, has one obvious limitation: it does not consider evaluation of an individual to himself.

Unlike individuals and families, however, if society as a whole is "defined to include everyone, including the individual whose values are being considered, then his contribution to the group is the present value of his gross future earnings".[3] This definition is a broader one and is concerned with valuing man's total gross output as first initiated by Sir William Petty.

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1. Weisbrod, B.A., "The Valuation of Human Capital", loc. cit., p. 428.

2. Ibid., p. 36.

3. Ibid., p. 36.

A question arises, then, in estimating future income loss as to whether or not the loss of consumption by the victim should be deducted in cases of fatalities. Does the loss of consumption by the victin, ceteris paribus, be considered as a loss to society? The answer to that question involves a value judgement. It depends on whether all consumption should be treated as a cost of production or a subsistance cost. Society as a whole is solely concerned with total output, of which consumption is the major component. If man is not a machine and if consumption is the ultimate end of economic activity,[1] then man's net contribution to output after consumption is not relevant.[2] Our concern here, is to treat all consumption as income. The "gross" approach to value human beings is used and no distinction is made between the income loss resulting when an individual is killed in an automobile accident, and when he is injured (permanently or completely).[3]

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1. Keynes, J.M., The General Theory of Employment Interest and Money, London: Macmillan Co., 1964, p. 104.

2. Weisbrod does not explicitely choose between the "net" or "gross" concepts. He develops and calculates estimates of consumption and employs them in his estimates of economic losses. Ibid., pp. 35-36, 52-55, 60-61 and 64-69.

3. Holmes, R.A., op. cit., pp. 145-146.

(P_a^n). Life Expectancy. This variable is probably the most accurate because of past previous years experience. Increasing survival probabilities (by better health for example) will certainly reflect the importance of earnings prospects. It should be pointed out, however, that if it is regarded as an addition to human capital in absolute size, it may not increase its value. For young people who either are not in or just entered the labor force, increasing life expectancy will actually reduce the per capita income but, in contrast, the expected future earnings will rise or fall proportionately less then per capita income. Similarly, improving life expectancy among the older persons could rise per capita income but their expected per capita earnings would fall.[1]

Conceptually, increasing the value of human capital by increasing their expected earnings will occur if the increase in survival probabilities is accompanied by an increase in thestock of physical capital.[2] It should be pointed out finally, that probability of surviving each

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1. Weisbrod, B.A., "An Expected Income Measure of Economic Welfare, loc. cit., p. 358.

2. Kiker, B.F., The Concept of Human Capital, loc. cit., p. 34.

year is underestimated. Because of better health in all age, this leads to a small downward bias in valuating human capital by age and by sex.[1]

(E_a^n) The Expected Labor Force Participation Rates.

In estimating human capital values one cannot avoid the problem of probable future employment. Account needs to be taken, then, of probabilities of employment in estimating future overestimation of capital values of man. If we assume that all individuals killed or injured in automobile accidents would have remained employed throughout the remaining of their working lives, overestimates of income loss would result.

In this study, we treat individuals just as we find them at the time of the accident. Those who are unemployed are estimated to suffer no future income losses because of the accident, while those who are employed at the time of the accident are estimated to suffer no future unemployment, and thereby no change in earnings.[2]

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1. In our model, earnings are ajusted to take account of the probability that a person (of a specified age group) actually living would realize the earnings to a future age. We also arbitrarily assumed that in all cases the life expectancy come on the average, at 74 years of age.

2. This assumption could be explained by the use of cross-section data on earnings and the difficulty of making dynamic predictions on future employment.

The average employment rate might be an appropriate measure in long run but in one year the rate of employment forecasted could present a wrong figure. One could use the employment probability, but still difficult to specify to a percent point. Practically, the impossibility of predicting probable employment for individuals in estimating future income loss could be solved by being concerned with an overall picture of it and assuming that the rate of employment remain unchanged.[1] This assumption could be reinforced by the fact that determining future full- employment is difficult. Finally, difference in labor-force participation rates may occur within a country because of technical change in a specific region, of employment opportunities, and the difficulty of mobility.[2]

(r) The Discount Rate. For some purpose it is better not to discount future income losses. For example, in order to estimate the total cost of accidents, it would be better to add up total losses without discounting because the total cost of accidents in any year consists not only of the cost of accidents occured in that year, but also the continuing costs of accidents occured in previous years. This approach

1. Holmes, R.A., op. cit., p. 145.

2. Future income loss also depends on expected length of working life which depends in turn on life expectancy, institutional conditions which determine the age of entry into and exist from the labor force, as well as economic conditions which affect the decisions of "marginal workers" on whether or not to seek employment.

assume a stable level of accidents, and therefore provides estimates of total costs over a long period of time in which the accident rate remains at the current level.

We are, however, primarily concerned about measuring the social loss to society of individuals' products or the social gains that could be saved if society takes appropriate measures to improve road safety that could save lives or prevent injuries. Thus, in comparing costs with benefits of such measures, the present value of future income losses must be taken.

This raises the question of the appropriate rate of discount which is not easily obtained. Given the controversial arguments on what should be the appropriate rate of discount for public investments programs discussed in Chapter 5, what rate should we choose as to discount future income losses? For any government traffic safety program that save so many lives over a long period, the choice of the discount rate may have a great influence on the present value of human life saved from such a program. If we are not too casual in selecting it, and if we are guided by the desire to underestimate rather than overestimate the future income loss from fatalities, the social gain of safety program, which could increase the future flow of real national income, should correspond to the foregone rate of return on private investment.

A higher rate of discount is, thus, favored to estimate economic losses from deaths and injuries in traffic accidents. J.A. Seagraves has suggested that the appropriate rate of discount for government projects should be at least the same as would be employed in the private sector. Following the Harberger's recommendations for government actions in selecting among investments, Seagraves has proposed the following approach in estimating the social rate of discount.[1]

Discussing separately the adjustment for risk, the effect of taxes and of inflation on project appraisal and adding up these seperate adjustments, Seagraves proposed that the social rate of discount be estimated in the following manner.[2]

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1. Seagrave, J.A., op. cit., pp. 431-449 and Harberger, A.C., "On Measuring the Social Opportunity Cost of Public Funds", in The Discount Rate in Public Investment Evaluation (Conference Proceedings of the Committee on the Economics of water Resources Development, Western Agricultural Economics Research Council, Report No. 17, Denver, Colorado, December 17-18, 1968), pp. 1-24

2. Ibid., p. 448.

TABLE 2

The Determination of the Social Rate of Discount: An Example

Basic factors affecting the social rate of discount	Social rate of discount	
	Lower limit %	Upper limit
Yield on Class A corporate bond (1969)	6,7	7,2
Risk premia for government portfolios	2,0	4,0
Corporate profit and proporty taxes	4,3	6,0
Marginal productivity of capital	13,0	17,2
Adjustment for added savings	-1,5	-1,5
Social rate of discount in money terms	11,5	15,7
Adjustment for expected inflation	-3,5	-1,5
Social rate of discount in real terms	8,0	13,2

Thus, according to Seagraves, government investments should be made to "show a high enough rate of return to pay normal interest plus a risk premia of 2 - 4 per cent, plus 3, 4 - 6, 0 per cent for taxes. This means that the minimum social rate of discount for 1969 would fall between

8 and 13 per cent in real terms, and between 12 and 16 per cent in money terms".[1] This approach to arrive at a specific social rate of discount could be reasonable one, but agreement on this procedure could not easily be obtained depending on whether one considers the specific assumptions that led to these numbers or whether one considers as important the goals and the logic.

For our puspose of estimating the economic losses of fatalities we arbitrarily choose a rate of discount that corresponds to the individuals' preferences, that is the rate at which the individuals can be expected to divide their investments equally between equities and fixed income securities, whose long-term yields are taken to be 12 per cent and 6 per cent respectively. This assumption produces a discount rate of about 9 per cent and 8 per cent after a conservative adjustment or 1 per cent for annual rates of inflation.[2] Our subsequent estimates of economic losses are therefore based on an 8 per cent discount rate for future income losses from traffic accident deaths and injuries.[3]

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1. Ibid., p. 449.

2. See Holmes, R.A., op. cit., p. 145.

3. Estimates based on both an 11 per cent and a zero rate of discount could be produced for comparative purposes, although these alternative estimates are not our concern.

6.3.3 Data Used for the Estimation of the Present Value

The data used in the computation of the present values of gross future earnings by age and sex appear in Table 3 and Table 4. Tables 3 and 4, columns (1) show age group; columns (2) - (4) of Table 3 contain the figures needed for calculating the capital value of males and, therefore, the economic loss to society from traffic accident deaths and injuries; columns (2) - (8) of Table 4 contain the figures for females. Table 3, column (2) shows the money contribution to market output of an employed male within a specified age group. In order to find the average earnings for all males, our series on earnings are multiplied by column (3) which shows the labor force participation rates. The last data needed for males are the expected life probabilities through a given year shown in column (4).

TABLE 3

Data for Males used in the Computation of Present Values of Gross Future Earnings, by Age Group

Age Group[1] (1)	Money Earnings (2)	Labor Force Participation Rates[2] (3)	Expected Life Probabilities through year (4)
0 - 4	$ 0	- - -	0,9988
5 - 14	0	- - -	0,9994
15 - 19	1142	0,405	0,9986
20 - 24	2542	0,907	0,9984
25 - 34	3845	0,976	0,9984
35 - 44	4366	0,977	0,9972
45 - 54	4274	0,958	0,9924
55 - 64	3897	0,866	0,9803
65 - 74	2890	0,291	0,9559

Sources: Canada, Dominion Bureau of Statistics, Cat. No. 94-536 for column (2); Cat. No. 94-508 for column (3); and Cat. No. 84-515 for column (4).

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1. For simplicity of estimation in our formula, we assumed that the maximum value of age N for both males and females be 74.

2. Our earnings figures are also adjusted by the labor force participation rates which show the percentage of persons at each age group which may be expected to be employed.

TABLE 4

Data for FEMALES used in the computation
of Present Values of Gross Future Earnings, by age group

ge Group (1)	Money Earnings (2)	Labor Force Participation Rates (3)	Average Money Earnings (4)	Number of Responsability Units (5)	Value of Household Services to Others (6)	(4)+(6) Value of Total Production (7)	Probabilities of Surviving Through Year (8)
0 - 4	0	---	0	---	0	0	0,9990
5 - 14	0	---	0	---	0	0	0,9986
5 - 19	1150	0,324	373	1,3	1900	2273	0,9995
0 - 24	2007	0,488	979	2,2	2550	3529	0,9995
5 - 34	2206	0,281	620	3,4	3250	3870	0,9992
5 - 44	2141	0,301	644	3,3	3200	3844	0,9983
5 - 54	2240	0,322	721	1,8	2300	3021	0,9957
5 - 64	2180	0,232	506	1,1	1800	2306	0,9895
5 - 74	1588	0,058	92	1,0	1700	1792	0,9723

ources: Canada, Dominion Bureau of Statistics, Cat. No. 94-536 for column (2); Cat. No. 94-508 for column (3), and Cat. No. 84-516 for column (4). Data for column (5) are taken from Cat. No. 93-520 and column (6) from our computations.

Table 4 contains the figures needed for calculating the capital value of females. Columns (2) and (3) are entirely analogous to the columns (2) and (3) for males. At this point, however, it is important to take account of the non-market production by females in the form of household services in our estimation of the economic costs of traffic accidents. Generallly, National Accounts exclude housewives' services from the nation's output. The household production (which is consumed by the producer or members of the same household) is considered to be outside the boundary of production because of the statistical difficulty of measuring the physical volume of household production and to find a satisfactory valuation for it.[1] This non-market production does not justify, however, an assumption that the housewives' services are not valueless.

Following the replacement cost method we assune that the housewives' production are directly related to the number of other persons in the household units, and that the value of their household services is a function of their age.[2] If the replacement cost of housewives is estimated to involved the household

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1. Canada Dominion Bureau of Statistics, National Accounts Income and Expenditure 1926-1956, loc. cit., Part II, The Conceptual Framework of the National Accounts, pp. 106-107.

2. See Weisbrod, B.A., The Economics of Public Health, loc. cit., p. 56 and Appendix II, pp. 114-119.

services of a live-in-housekeeper as well as a day-worker on the whole week, the annual replacement cost is $3500[1] assuming an average family consisting of a father and three children under 15 years of age. Thus, for "responsibility units" (R.U.) = 4, the value of household production is $3500 per year. For R.U. = 0, that is for a single person, the value of household services is zero, since the services performed to others would cease if the individual does die.[2] For injured housewives with no children under 15 years of age, we assume that the husband (likewise is the case of a single man) would employ the services of a housekeeper on the basis of four hours per day. Then, at R.U. = 1, the annual replacement cost is $1700.[3] These three points [(0, 0), (1, 1700), (4, 3500)] gives us a function relating the replacement cost of housewive's services (C) to the number of responsibility units (R.U.). Connecting these three points by a smooth curve, we obtain a function relating the replacement cost of housewive's services (C) to the number of responsibility units (R.C.).

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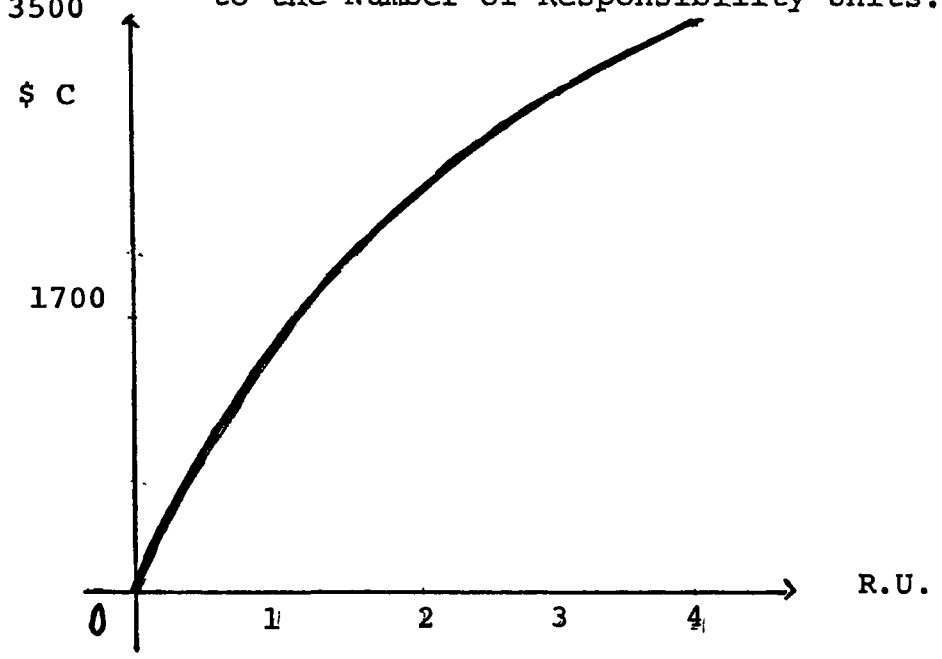
1. Holmes, R.A., op. cit., footnote 11, p. 145.

2. Weisbrod, B.A., op. cit., p. 115.

3. Holmes, R.A., op. cit., p. 145.

FIGURE 5 - Value of Housewives' Production, according to the Number of Responsibility Units.



The next information needed is the average number of responsibility units by age of female. For simplicity we use published data on husband - wife families by age having children of 15 years of age and under at home. From these figures we add the number 1 (to take account of the husband) and we obtain an estimate of the average number of responsibility units of a woman in a given age braket.[1]

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1. Data regarding the total number of women in various age classes (married, single, widowed, divorced) are available. But this is not sufficient. What is needed, but not available, is to know how many of the married women at each age childless; how many have one child? Two? How many of the single women live alone; and how many live in the household of others? See Weisbrod, B.A., op. cit., p. 117.

TABLE 5

Average Number of Women's Household Responsibility Units, by Age Group

Age Group (1)	Average Number of Children of 15 Years Age and Under at Home and Per Family (2)	Average Number of Responsibility Units of a Women (2) + 1 (3)
15 - 19	0,3	1,3
20 - 24	1,2	2,2
25 - 34	2,4	3,4
35 - 44	2,3	3,3
45 - 54	0,8	1,8
55 - 64	0,1	1,1
65 - 74	0,05	1,0

Sources: Canada Dominion Bureau of Statistics, Caracteristics of Husband - Wife Families, Cat. No. 93-520 for column (2). The DBS gives the average number of children of 15 years of age from the age brakets "under 25 years to 65 years and over" so that the number of children for the age group 15 - 19 has been estimated by the difference between the average "all husband - wife families and the computed average for the given age brakets. Column (3) is from computation.

The value of total production by the average female column (7), Table 4, is obtained by the sum of her market-oriented production, column (4) and her household production, column (6). The series of column (6) are directly obtained from Figure 5.

Having all the data needed and having decided to use 8 per cent discount rate, the estimation of the present values of gross future earnings appear in Table 6. With these present values we can compute the economic losses from traffic accident deaths and injuries.

TABLE 6

Present Values of Gross Future Earnings, Canada 1961, by Age Group and Sex, at 8 per cent Discount Rate.

Age Groups (1)	Males ($) (2)	Females ($) (3)	Females Without Household Services ($) (4)
0 - 4	10,090	13,225	2,603
5 - 14	14,867	22,145	3,796
15 - 19	32,115	42,275	8,252
20 - 24	44,271	47,744	9,768
25 - 34	50,400	47,805	8,150
35 - 44	50,187	42,707	7,903
45 - 54	41,796	32,167	7,020
55 - 64	26,668	22,384	3,925
65 - 74	5,819	12,624	652

Source: Our computations. For all ages groups, present values of gross future earnings were obtained from data in Table 2 (males) and Table 3 (females)

Economic Losses from Death. The loss of productivity by a fatally injured or killed person from traffic accident is a loss to the nation. Since we have assumed that the marginal contribution to the national product of an employed person is measured in terms of earnings, then the sum total of earnings lost due to accident provides a measure of this loss productivity. For the fatally injured or killed, the figure used is the present value of all gross future earnings lost. The computation of these earnings losses are preformed in Table 7 for both sexes. The economic losses to the nation (or society) total $121 million for 3,580 death cases from traffic accidents if future earnings loss is discounted at 8 per cent. For one assuming that the housewive's services to others are of no economic value, the economic losses total then $99, 414 million.

Economic Losses for Injuries. Just as traffic accidents fatalities means permanent loss to society of a producer, so disability due to injuries means temporary loss of a producer. Estimates of these economic losses do not depend on the disocunted rate since these injury cases do not involve appreciable future earnings losses. To estimate the magnitude of gross earnings losses due to temporary disability resulting from traffic accident injuries we need and average estimate of working days lost reflecting the loss of earnings

TABLE 7

Gross Future Earnings Losses from Traffic Accident Deaths, Canada 1961, by Age Group and Sex, at 8 per cent Discount Rates.

Age Group (1)	MALES		FEMALES			Total Present Values of Foregone Future Gross Earnings (3)+(5) ($000) (7)	Total Present Values of Foregone Future Earnings Without Household Production (3)+(6) ($000) (8)
	Number of Deaths (2)	Present Values of Foregone Future Earnings ($000) (3)	Number of Deaths (4)	Present Values of Foregone Future Earnings ($000) (5)	Present Values of Foregone Future Earnings Without Household Production ($000) (6)		
0 - 4	154	1,554	110	1,455	287	3,009	1,841
5 - 14	320	4,757	132	2,923	501	7,680	5,258
15 - 19	276	8,864	97	4,101	800	12,965	9,664
20 - 24	403	17,841	70	3,342	684	21,183	18,525
25 - 34	462	23,285	90	4,302	733	27,587	24,018
35 - 44	364	18,268	100	4,271	790	22,539	19,058
45 - 54	302	12,622	89	2,863	625	15,485	13,247
55 - 64	229	6,107	99	2,216	389	8,223	6,496
65 - 74	216	1,257	77	972	50	2,229	1,307
All Ages	2,726	94,555	864	26,445	4,859	121,000	99,414

Source: Mortality data from Canada, Dominion Bureau of Statistics, Vital Statistics, Cat. No. 84-202. Ottawa: Queen,s Printer, 1963, p. 162. Present values are based on figures in Table 5.

due to temporary inability to perform working activities.[1] Having this figure with the average earnings of all the population by age groups and sex and the number of injury cases accidents, the value of production losses expected from traffic accident injuries are derived in Table 8.

Table 8 shows that for 71419 cases of nonfatal injuries, the actual production losses amount to $4,536 million and to $3,864 million if the household production is excluded. These results do not show the relevance of reduced working efficiency or lower earnings received due to permanent partial disability as a result of traffic accident injuries. It is certainly a form of economic loss from injuries, but no attempt is made here to measure its magnitude.

It is interesting to note from the above results, that the economic value of a person could be estimated from the existing market values rather than resorting from our model. It has been shown however that the market compensation system is for a number of reasons quite unsatisfactory.[2]

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1. Disabling injury is defined as an injury which prevented a person from performing his usual acitvities. For a person regularly employed, it means a disturbance of ususal activities marked by absence from work. For housewives, it is the inability to perform usual housekeeping duties.

2. Compensation includes amounts received from victims' own insurance (automobile, life, medical, hospital, accident), as well as amount received from other persons or persons responsible on their insurance companies.

TABLE 8

Production Losses Expected from Traffic Accident Injuries, Canada 1961 by Age Group and Sex

Age Group	MALES		FEMALES			Total Production Losses ($000) (3)+ (5)	Total Non-household Production Losses ($00 (3)+ (6)
	Number of Cases	Production Losses ($000)	Number of Cases	Production Losses ($000)	Nonhousehold Production Losses ($000)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0 - 4	2322	0	1287	0	0	0	0
5 - 14	5920	0	3026	0	0	0	0
15 - 19	6640	182	3803	207	105	389	287
20 - 24	7662	467	4496	381	217	848	684
25 - 34	8723	805	4925	475	261	1,280	1,066
35 - 44	5993	628	3375	311	173	939	801
45 - 54	4125	423	2364	171	127	594	550
55 - 64	2650	248	1532	85	80	333	328
65 - 74	1604	111	972	42	37	153	148
All Ages	45,639	2,864	25,780	1,672	1,000	4,536	3,864

Source: (See following page)

Source for Table 8: Data of injury cases according to age group and according to sex are available from Canada, Dominion Bureau of Statistics, Motor Vehicle Traffic Accidents 1961, Cat. No. 53-206, Ottawa: Queen,s Printer, 1962, p. 13. Unfortunately, data according to age group and sex are absent. We thus assumed that the overall ratio of injured females out of total injured be distributed among the age group. The losses figures for each age group assumed an average annual number of 6 working days lost of production per case corresponding to 2.4 per cent of a working year on a basis of 21 working days a month. Not being available from Canadian official publications for the year 1961, this figure has been taken from the U.S. Department of Health, Education and Welfare, Disability Days, U.S., July 1961 - June 1962, National Centre for Health Statistics Series B - No. 40, p. 6. This figure corresponds to the average annual number of work-loss days per person injured resulting from types of accidents that are leading causes of disability in the United States per employed person for all ages (17 and over) and for all activities. It is a reasonable estimate for Canada if we consider the average annual number of disability days per gainfully employed person corresponding to 8.5 days for all ages (substracting the weekend, we end up with 6.5 days) from the last Canadian Sickness Survey 1950-1951, Canada, Dominion Bureau of Statistics, Disability Among the Gainfully Employed, Cat. No. 82-521. The values or production figures in each age group are taken from Table 3 (males) and Table 4 (females). Notes that the relevance of the number of injury cases does not reflect the true number of injuries for both sexes because complete breakdown by age and sex is not available for the Province of Quebec.

R.A. Holmes has shown in his study that the overall amount of compensation provided to the victims of automobile accidents falls short to their economic losses resulting from the accidents. He argued that for minor injury cases with average compensation equal to 80 per cent of average economic losses and an average net cost to the individual of only $50 is adequately compensated. However, with serious injury cases and the survivors of fatalities whose average compensations are only 45 per cent and 20 per cent respectively of average economic loss, and whose net costs are $4,000 and $23,000 respectively, are not adequate.[1]

Other Economic Losses. Our estimates of other economic losses include expenses incurred for such things as medical and hospital treatment, and property damage to automobiles. The latter consist of losses of capital goods due to accidents. It should be valued at repair or replacement cost of the property, whichever is lost. For Canada, damage from motor vehicle traffic accidents total $84,696 million in 1961.[2]

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1. Holmes, R.A., op. cit., pp. 148-149. He stated that for full compensation of economic loss a discount rate greater than 30 per cent would be needed, In short, his additional findings sate that compensation which is provided often comes too late, and is unfairly distributed by means which adversely affect the public image of the automobile insurance industry. Moreover, he found that the ignorance of the parties involved and their ability to wait for compensation exert undue influence on the amount of compensation received. Ibid., pp. 149-151.

2. Canada, Dominion Bureau of Statistics, Motor Vehicle Traffic Accident, 1961, loc. cit., p. 6. This figure excludes the Province of Quebec because the complete breakdown of the number of accidents resulting in property damage ($100 or over) is not available.

The economic costs of hospital and medical treatment as a consequence of traffic accident injuries can be evaluated from the following data:

1) the average length of stay in hospital. For Canada as a whole the average length of stay in public general or allied special hospital was of 11.1 days for accidents, poisonnings and violence (by nature of injury).[1]

2) the average total cost of a day-care total $21.29 in 1961.[2] The total hospital cost for 11 days amounts to $235;

3) the lost data needed related to the physicians' and surgeons' services. On the basis of schedules of fees for surgery and supporting services an injured individual could be expected to pay an additional $150.[3]

For all injured persons that need medical and/or hospital care, an average of $385 could be expected to be for hospitalization and treatment. For 71419 cases of

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1. Canada, Dominion Bureau of Statistics, Canada Year Book 1963-1964, Ottawa: Queen's Printer, 1965, p. 283.

2. Ibid., p. 175. It includes salaries and wages, medical and surgical supplies, drugs, food, dietary, linen service housekeeping, operation and maintenance of the physical plan, rent, interest, etc..

3. This figure has been estimated from the Schedule of Fees (1961) published every year by the New Brunswick Medical Society and the Ontario Medical Association for fractures and wounds. The fees vary from a minimum of $10 to a maximum of $350 depending of the seriousness of the injury. For all the injuries an average of $150 for physicians' and surgeons' services may not be impossible.

nonfatal (minor and serious) injuries, the total economic costs associated with hospital and medical care as a consequence of traffic injuries total $33.494 million.[1]

Other economic losses such as the time lost, insurance and other administrative costs, indirect costs to employers are excluded. The time lost by injured workers except the working days lost, could be important. The time lost on the day of the injury or the time required for further medical treatment following the injured person's return to work are quite difficult to estimate. More difficult is the time lost by person with nondisabling injuries and persons with no injury who stopped to help the injured persons or discuss the accidents. It could be valued at the going wage. Such data on time lost cannot be found in any official publication.

Table 9 shows that the principal economic loss to society results from death and represents one-half of the total monetary loss. While the property damage represents more than one-third of the loss and that medical and treatment cost are relatively important, the loss of earnings due to injuries represents only two per cent of the whole loss. This is

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1. This figure does not take into account the expected future medical expenses. For some injured people these expenditures are certain and for others they are uncertain to be incurred.

due to the relatively small number of working-days loss.[1] Of course, this ratio could have been relatively much more important if the form of losses could have been break-down by categories or road users or by education level.

TABLE 9

Total Economic Losses from Traffic Accidents and Per Cent of Lost out of Total Loss, Canada, 1961.

Form of Losses	Economic Losses		Nonhousehold Economic Losses	
	Total ($000)	Per Cent	Total ($000)	Per Cent
Death	121,000	50	99,414	45
Injury (Foregone Earnings)	4,536	2	3,864	2
Property Damage	84,696	35	84,696	38
Hospital and Medical Care	33,496	13	33,496	15
All Forms (Total)	243,728	100	221,472	100

1. If a working-days loss figures by categories of road users by importance of the injuries, by age and sex could have been obtained, it is not impossible that our estimation of foregone earnings due to injuries could vary between 2 and 50 per cent of the total economic loss depending on the importance of the injuries (minor or serious) and on the length of stay in hospital or under medical observation.

6.4 Concluding Remarks and Limitations

Economic Loss. We have estimated the aggregate economic losses due to traffic accidents. These losses include earnings lost from traffic accident deaths and injuries and also expenses incurred for medical and hospital care and damage to automobile. Summarized in Table 9, these forms of losses present a total loss figure of 243,7 million of dollars.

The largest economic loss of persons who are seriously injured or killed in automobile accident is obviously the income loss. It represents an estimated figure of 121,7 million of dollars for a total number of 3,590 killed. For 864 females killed, the estimated losses represent 21 per cent of the total income loss, and for 25,780 injured females out of a total of 71,419 injured in traffic accidents, the foregone earnings represent 37 per cent of 4,5 million of dollars foregone from traffic injuries (Tables 7 and 8).

We have seen in the above discussion of our model's components that the income loss is difficult to measure accurately because it involces dynamic analysis of many variables. Since noneof these variables can be precisely predicted, we have choosen approximations which led us to conservative estimates at every stage of our economic losses.

Incommensurable. Our estimates of economic losses using a "gross" valuation for monetary value of man, have explicitly left out of computation any allowance for psychic losses. The "gross" formula is occasionally supplemented by a suggestion that auxiliary calculations be made for psychic losses due to such things as the loss of comfort and happiness, physical pain, mental auguish and bereavement resulting from death or injury of a family member,[1] or from the anticipation of possible accidents.

These types of losses are incommensurable and have been omitted completely from our estimates. This omission should be kept in mind when interpreting the results. Although these losses cannot be quantified in any general satisfactory manner, psychic losses should be presented as parameters to the decision-maker.

If our "gross" formula is regarded as only part of the total measurement of the automobile accident costs what would be the correct valuation of the psychic losses. It has been argued that the correct valuation to put on death and thepsychological and sentimental burden carried by the victim's relatives is the amount that society or

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1. Mishan, E.J., "Evaluation of Life and Limb: A Theoretical Approach", Journal of Political Economy, 79 (July/August, 1971), p. 688.

community would be willing to pay to prevent an automobile accident death.[1] This valuation seems to defy any economic measurement and perhaps the compensation system or courts awards could serve as a close approximation of total measurement of losses from automobile accident deaths. We have seen that the compensation system for fatalities cases is quite unsatisfactory. However, compensation through court awards could play an indirect role in valuations of life. Given the total economic costs, compensations for psychic losses awarded by the courts could make it possible to obtain an average opinion as regards to the amount a collectivity could spent to avoid noneconomic costs of traffic accident deaths and injuries.[2]

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1. Thedie, J., and C. Abraham, op. cit., p. 590.

2. For discussion of affective factors and the role of the courts in valuating human life, see Ibid., pp. 593-594. It should be pointed out also that other considerations could be worth mentioning. Since most decisions made are concerned with the future and with estimation of both costs and benefits one can never prescribe an action with absolute certainty. In the case of traffic safety decisions, there is a certain range of values that a collectivity can afford to pay to prevent automobile accidents. If the value of life is assumed to be unknown, there exists a technique, called sensitivity analysis, which experiments with parameter values as to determine where the critical decisions are most affected. For example, this technique could be very useful to a decision-maker concerned with traffic safety remedies, to know that below a certain dollar value of human life one action is optimal, but that above this value, another action would be preferable. The use of expert opinion could be of a very great help in estimating the incommensurable losses. To mention one, the Delphi technique is an iterative procedure for integrating the opinions of several experts. For more details on both techniques, see Quade, E.S. (ed.), Analysis for Military Decisions, Chicago: Rand McNally, 1964 and Dalkey, N., and O. Helmes, "An Experimental Application of the Delphi Method to the Use of Experts", Management Science, 93 (April,

Before ending this Chapter, a few words on "net" approach to value human life are of interest. Following the "gross" formula, our procedure is rationalized in that values present positive contributions to production. This is not the case, however, if the "net" approach is used to evaluate the individual's net contribution to production. What society matter in that case is the resulting loss or gain to society from road fatalities.[1] Even if this method is satisfactory on economic grounds, it is undersirable for policy decision-making, in that it "has no regard for the feelings of the potential decendants" and the contemporaneous. It restricts itself to the "interest only of the surviving members of society" it ignores society ex ante and concentrates wholly on society ex post".[2]

Finally, the discount rate used to value the capital value of individuals carry a great relative significance when economic losses from automobile accident deaths are under

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1. This "cold-blood" attitude is either absurd or dangerous. Two ironically examples have been cited by Mishan, E.J., op. cit., p. 690: "Indeed if we could only kill off enough old people we could show a net gain on accidents as a whole", in Devons, E., Essays in Economics, London: Allen & Unwin, 1961, p. 108; and the net output method "suggests that society should not interfere with the death of a person whose net value is negative", in Ridker, R.G., The Economic Costs of Air Pollution, New York: Praeger, 1967, p. 36.

2. Ibid., p. 690.

consideration. Our estimation of present values of gross future earnings of individuals (Table 6), presents an evident shortcoming in that the $[0_1 - 14]$ and $[65-74]$ age brakets carry very small valuation. In case of fatalities, the $[0 - 14]$ age braket presents productive lifetimes in many years in the future, so that our discount rate (8 per cent) attaches little significance to the distant future. This should be looked as a shortcomings and due to the practical difficulties to choose a relevant discount rate to estimate the present value of human capital.

The results of Table 9 could be of a great help to policy decision-making. For a total of 125,5 million of dollars of production lost combined with the associated costs of 118,2 million of dollars, the total economic cost of 243,7 million of dollars per year could certainly be used as an indicator for public investment programs in traffic safety. Granted that the monetary losses could be breakdown by category of road users, the ranking of public investments by importance would certainly served as indicator for public action to save lives, prevent injuries, prevent hospitalization and treatment, as well as property damage due to automobile accidents. It could also be valuable for

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1. If the age braket $[15 - 64]$ shows relatively high values, they are frequently considered to be the greatest lost to society from fatalities while the lost of young $[0 - 14]$ are considered to be a very great loss to family.

educating a population of road users to the importance of supporting traffic safety devices.[1] One should keep in mind, however, that these total estimates, especially the estimated losses in production, are underestimated and represent only a minimum value that should be positively corrected by some kind of estimation, however crude, of the incommensurable losses left to the responsability of the decision-maker.

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1. If a cost study of safety measures is undertaken for different category of raod users, the conditions for an optimal allocation of public funds (out of a fixed budget) between different traffic safety devices are based on the principle that the ratio of Marginal Benefit (MB) of preventing additional death (or injury) and the Marginal Cost (MC) of preventing an additional death (or injury) or MB_i/MC_i be equal for all particular death (or injury) due to automobile accidents, i.e. for all i = 1, ...,n. See Weisbrod, B.A., op. cit., pp. 89-93.

Chapter 7. CONCLUSION

The concept of human capital has been investigated on both a micro and a macroeconomic basis and we have stressed the importance of the human capital approach as a useful tool of analysis in trying to understand and solve some economic problems. We now know from the overall discussion that emphasis must be laid on physical capital and human capital as two factors of production and that great benefits to society are expected to be gained from investments in human capital that lenghten productive life or preserve the existing stock of productive capacities.

First, the theoretical investigation pointed out why economists have been so reluctant in considering human asset as a useful analytical tool, and stressed the importance of taking account of the stock of human capital explicitely considered through in the National Account framework. Whatever criticisms can be made against the use of human capital as a decision criterion in economic and social policies, it seems almost impossible (at the present stage of economic analysis) to avoid using it.

Secondly, the role of human capital as an explanatory factor of economic growth was introduced in an aggregate

type of production function. Human capital was considered as potentially important as physical capital in explaining the total growth in output. Labor's productive capacities could be of great help in explaining the residual left unexplained in most classical and neo-classical growth models that have taken technical changes and the quality of labor-input into consideration. Indeed, by assuming that labor may grow both endogeneously and exogeneously and, by identifying and measuring the human capital components embodied in labor, the residual unexplained in most standard neoclassical growth model could be explained. Still, the problem of aggregating man's collection of human capital assets remain unsolved not only because human capital is assumed to be heterogeneous, but also both the qualitative and quantitative elements of labor are hardly separable.

Third, human capital assets are generally acquired at costs and the human capital concept provides a useful analytical framework that helps to understand man's investment in himself. Using an analogy with physical capital formation, investigation of human capital formation help to understand the relationships between labor productivity and earning capacities.

Man's human capital cannot be bought and sold. Although most goods and services produced with the help of labor and capital are traded on market and valued at market prices, no market mechanism is available for human capital. Man is paid for his services but his human capital is not marketable.[1] The absence of market for human capital is not an insurmountable obstacle to determine its market value. Using "price" or "rental" values for its services, human capital was measured indirectly by capitalizing his earnings to yield a present value of his productive capacities.

The use of the capitalization procedure for human capital formation is, however, not as straightforward as for

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1. This observation is questionable. Does a human capital market exist for hockey players for example? Is the value of human capital and the value of hockey player possessing it the same? The hockey player has economic ability. If natural ability and existing stock of human capital are the two most important inputs in the production of human capital then the latter may alter the shape of the production function and the process of acquiring additional or new human capital can be used to develop the former. By analogy with physical capital, human capital is embodied in the hockey player and should presumably increase his quality as a producing unit within the hockey team. Since his acquired human capital is inalienable it is questionable whether one should speak of it alone as capital: it is, if this view is taken, the skilled and talented hockey player who is the capital. The earnings earned by him are not high because his training is expensive but he expends much on training because the expected earnings are high.

physical capital. The anticipated returns from an investment outlay may be quite different at the optimization level because of investment-consumption dichotony. Other conceptual and practical difficulties such as the depreciation problem, difficulty of allocating the costs of human capital formation between investment and consumption, and the imperfections of the capital market in which human capital stock cannot be offered as collateral for loans; all these limitations, among others, leave the concept of human capital as a very particular type of capital asset. Although these difficulties make it hard to measure the stock of human capital, the concept is presented as an improvement of economic analysis and any use of it should not blind us about the conceptual and practical difficulties of its use.

It was not our intention to propose new definition or method of measurement of human capital value, but rather to understand the usefulness of the human capital concept and its great help in assessing capital value to man. Our main concern was the application of the concept to the measurement of economic losses to society as a consequence of automobile accidents.

If society is interested in preserving the life of its members, any investment that society undertakes to serve

this purpose should benefit its members. Thus, any social expenditure for improving road safety is viewed as preserving the stock of human capital in that it prevents death and injury. Preservation of human capital by some safety devices is of a public good nature. If safety can be improved the benefits it provides are distributed to every individual (or at least road users) whether or not they have paid for it. Individuals have generally no "willingness-to-pay" for the provision of a public good. Since it has the characteristic to be enjoyed by all in its use, and since payments by each user may be so small, the amount individuals consume has no observable effect, and the market allocation mechanisms break down. Safety cannot be sold, though it may have value to each individual in a collectivity and it becomes a government concern.

The human capital approach to assign a money value to human beings is to estimate the individuals' contributions to society by capitalizing the present values of their expected future income streams.[1] This approach has proved

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1. Another method of valuation has been advocated by some authors. This method takes the decision theory approach under uncertainty to evaluate the rational decision making for collective investments in traffic safety from the individuals' actual decisions. See especially Drèze, J., "L'Utilité sociale d'une vie humaine". Revue française de Recherche opérationnelle, 1962, No 23, pp. 93-118; Schelling, T.C., op. cit., pp. 127-176, and Mishan, E.J., op. cit., pp. 687-705.

to be a starting point to estimate the human capital losses resulting from traffic fatalities and it represents an explicit measure which gives a criterion for life saving decisions.

One must be aware, however, of the explicit distinction that must be drawn between the value of individuals and the value of their human capital. The benefits society is expected to gain from road safety programs (like improvements in the human factor, the vehicle factor, and the road factor) are in the form of preventing current econimic losses (income losses and other economic costs). The income or production losses due to traffic accident deaths and injuries have been estimated to 125,5 million of dollars and, the corresponding associated measurable costs, to 118,2 million of dollars amounted to a total economic lost of 243,7 million of dollars for all men and women killed and injured in traffic accidents. These results do not, in any case, suggest that the benefits lost should be only in the form of economic losses. Apart from the static analysis which already underestimated our results, the total economic losses should not be interpreted as final. They could be viewed as preliminary estimates, suggesting that these losses are of a minimum value. Indeed, the estimation of the present values of individuals future productivity does not indicate at all their worth as human

beings. The values individuals place on themselves have no measuring relation to their human capital. Psychic and affective elements are not included in the evaluation of human capital. In case of traffic fatalities, they also represent real losses though they are impossible to quantify. Unless policy-markers do not assign (intuitively or not) a dollar value to these incommensurables, the analysis of losses is, therefore, quite incomplete and may not be a complete guide for public action in the area of traffic safety.

Investment costs or improvement costs of traffic safety programs has not been investigated. These costs remain to be estimated as to allocate efficiently a given public budget for traffic safety among accident fatalities. If one decides to use the costs-benefits ratio, the greatest difficulty (apart from the choice of an appropriate discount rate which is crucial to evaluate investment projects but which seemed to offer no agreed way of selecting it) arises from assigning convincing money values to many of the benefits of traffic improvement. One alternative is to use the cost-effectiveness ratio that could be expressed in different kinds of units as to pay attention to intangibles and incommensurables. This should therefore provoke further research in this area of inquiry. Until better knowledge of how to estimate

intangibles and until estimates of incommensurables are available, public investment decisions concerning the use of resources devoted to traffic safety (among others), will have to base part of the decisions on qualitative evidences or intuition.

On the other hand, if better road safety is desirable and that knowledge and technique exist to improve safety, what would the recommendations be if one wish to investigate the policy implications of our results on deaths and injuries losses? Assuming, for our purpose, that road safety is perfect, we need then to compare our data on total dollar losses with the cost figures on road building.

Ideally, total costs are allocated in such a way as to equate expected marginal returns per dollar. This requires information on program expenditures per unit of output. Since our losses apply only to a single year (1961), the distribution of funds to safety should, in principle, be made with reference to the present value of all future losses. Conceptually then, the necessary and sufficient conditions for an optimum allocation of resources to road safety, given a safety budget, are MB_i/MC_i equal for all $i = 1,.....,n$; i.e., maximum total benefits will be obtained (from a fixed budget) when the benefits from additional expenditures to

traffic safety are equal.

From the results of our Chapter 6, we need to compute the marginal cost and the marginal benefit. Our total economic losses are of 244 millions of dollars for 75,000 cases of deaths and injuries. The result, (3,253 dollars) indicates the average total losses per case, wich are of course, the average benefits obtainable by preventing an accident. In absence of more specific informations on the nature of the particular cases, we may expect these average benefits figures to be the same as the marginal ones which we need. This implicitely assumes that the benefits remain constant as prevention expenditures change.

If the hypothetical cost to be spend on prevention of accident is taken out of a one million of dollars per mile of perfect road safety then the marginal cost per case is 13 dollars. Providing that the benefits of preventing an additional case of death or injury do not rise as more cases are presented and conversely for costs, then

$$\frac{MB}{MC} - \frac{\$3253/244}{\$13\ x}$$

where MB is the value of an individual per mile perfectly safe and x is the number of miles of road perfectly safe.

This suggest that the marginal cost could varied between 13 dollars and 3,253 dollars over the number of miles depending on that the number of miles perfectly safe vary between 1 and 244 miles. Of course, this analysis depends heavily on some implict assumptions such as: there exists only one investment project and that this project is only for traffic safety; that any additional mile perfectly safe is an average mile and that all individuals use this highway system with the same intensity and all will drive this additional mile.

However, apart from our assumptions, the policy maker is subject to many constraints and most of the time, when concerned with traffic safety, decisions are made at the expenses of others. Arbritary choices are often made and the number of miles of a perfectly safe highway could be anywhere between 1 and 244 miles.

Many other problems still remain to be solved. Among others, are the value conflicts and the trade-offs underlying the safety problem. Traffic safety can be identified as a problem with technical, psycho-sociological and values dimensions. This complex system rarely achieves all of its goals equally well. Many times objectives are achieved at the expenses of others. If the traffic system is assumed

to be rationally conceived, the trade-offs are made explicit and could be resolved. However, the identification of all the objectives of a highway system often presents objectives that maybe diverged as well as overlapped between the government, the individuals and the automobile industry.

The government is generally concerned with the well-being of the nation. But what constitutes the national welfare? The individuals' objectives could be safe, economic, rapid and convenient road transportation, which the automobile industry's objectives, in large part economic, try to give satisfaction to the individuals' incentives. The question to ask then is: can all these objectives be achieved simultaneously? Any solutions to the safety problem and, more generally, to the highway problem could be very costly and could involve limitations of individual choice. There is no doubt, however, that there is a desirable level of automobile accidents "in the sense that it is a necessary concomitent of things of greater values to society", and that the automobile is central to our way of life. It has a "large credit balance in the matter of lives" and influences our living, our working, and provides many satisfactions.[1]

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1. WILLIAMS, J.D., "The Nonsense About Safe Driving", Fortune, 58 (September, 1958), pp. 118-119.

However, these conveniences and satisfactions have been reached at a cost, and, in many instances, inconsistencies arise in the trade-off between them and the human cost, and the way the trade-off is handled provides a "test" of the rational economic behavior and society or individual's personal or humanitarian feelings.

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