EVALUATION OF LEISURE TIME FOR NATURAL RESOURCE ACCOUNTING

by

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ABSTRACT

Critics of the current system of national accounts, which extends Gross Domestic Product accounting, believe that the system has to be revised or changed because of its failure to account for the depletion or degradation of environmental resources and for leisure. Computations of Gross Domestic Product and most indices to measure economic welfare, omit leisure time.

In *Accounts Overdue* (1992), the Tropical Science Center in Costa Rica and World Research Institute, collaborated to analyse the changing state of the country's forests, soils and fisheries from 1970 to 1989. Another World Research Institute publication entitled *Wasting Assets: Natural Resources in the National Income Accounts* demonstrates that natural resources can be treated similarly to capital in national accounts. To address these issues, this study was conducted to develop a theoretical model to incorporate leisure and other environmental goods and services into the computations. The proposed model is then compared to Nordhaus and Tobin's (1980) measure of leisure that follows the average wage method.

The proposed method implements techniques of decision theory, and applications to two subjects are reported here. For these respondents, the true marginal wage associated with leisure was higher than the average wage for leisure.

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1. INTRODUCTION

A country's economic performance is normally measured by its Gross Domestic Product (GDP). GDP is a measure of all final goods produced in the economy for a given period of time. The international standard for national accounting is the United Nations' "System of National Accounts" (SNA), issued in 1968. The SNA in its modern form evolved from the publication of Keynes' General Theory of Employment, Interest and Money and the interest by governments during World War II and the early post-war period in the production and allocation of resources to competing uses. The current system of national accounts (SNA), is the basis of all GNP computations. Critics of SNA believe that it has to be revised or changed because of its failure to account for environmental services, leisure, and housewives services etc. Not only GNP, but most measures of economic welfare and cost of living that are based on consumer expenditures on goods and services, omit leisure time.and environmental services. The omission is partly explained by the fact that unlike consumer goods and services, leisure is purchased explicitly by not working.

Empirical analyses to estimate welfare indices mostly relied upon aggregate time series data (Kokoski 1987). These data provide information on national average changes in wage rates, but do not capture changes in hours worked at the household level due to increased labour market participation. While the entry of many part-time workers into the labour market may decrease the national average of hours worked per week, there may be an associated decrease in leisure for many households.

The inability of the current income accounting system to capture the depletion and degradation of natural resources, and account for leisure, are reasons justifying the need for resource accounting or the need to correct SNA. The SNA is currently undergoing an intensive revision in the light of the experience of individual countries and international agencies (ABS 1990).

As a response to the various criticisms associated with SNA, methods of Natural Resource Accounting (NRA) have been developed. NRA describes variety of methodologies which use accounting frameworks to present information on the environment and their use (Gilbert and James 1990). The different NRA approaches reveal that much of the NRA activity has focused on correcting GDP deficiences or on establishing complementary framework with the aim of guiding economic planning towards a broader perspective. Full examples are rare and most of the work done is theoretical in nature.

In *Accounts Overdue* (1992), the Tropical Centre of Costa Rica and the World Research Institute (WRI) collaborated to analyze the changing state of Costa Rica's forests, soils and fisheries from 1970 to 1989. Another WRI publication entitled *'Wasting Assets: Natural Resources in the National Income Accounts'* demonstrates that natural resources can be treated similarly to capital in national accounts, and it argues convingcingly that the accounts should be revised. To address the issues identified, the present study was conducted to develop a theoretical model to incorporate leisure and other environmental goods and services into the GDP computations. The results of the proposed model is also compared to the Nordhaus and Tobin (1972)'s innovative work and measure of leisure time which is based on the average wages .

The remainder of the paper is organized as follows. In section 2, the theoretical foundations of the proposed method discussed and analyzed. In section 3, the method is described, and in section 4, the data and empirical results are discussed and analyzed. A summary and conclusions follow in section 5 along with some recommendations for future research.

2. THEORETICAL FOUNDATIONS

The theoretical framework, to analyse the conflict between the objectives of maximisation of income and maximisation of leisure of the consumer, consists of two components, namely:

(a) the production possibility frontier (PP) and
(b) the indifference curve (IC).

The production possibility frontier defines how time can be efficiently allocated between the two objectives. The indifference curve defines how the consumer

empirically derived through mathematical programming model or by asking the respondent to define (estimate) the production possibilities of each objective The IC can be estimated through multiobjective analysis. The multiobjective utility analysis and the derivation of the optimal solution will be discussed in the succeeding sections.

2.1 Multi-objective Model

The theory of multi-objective analysis is presented in detail by Keeney and Raiffa (1976) and in Chankong and Haines (1983). The theory will be presented here in considerably less detail and will be based on Zeleny et al. (1988). For illustrative purposes, two of the objectives specified in the study namely, X_2 (consultancy income) and X_4 (leisure time) will be used in the discussion. The former is measured in terms of dollars earned per year whereas the latter is measured by number of hours per year.

The consumer is faced with several alternatives of allocating time between working for consultancy money and leisure. The situation is presented in Figure 1. Consulting income is presented in dollars per year on the vertical axis and will be the numeraire. The horizontal axis measures the hours of leisure spent per year. Each point in Figure 1 represents an alternative available to the consumer. The curve labelled PP is the production possibility curve and represents the boundary of feasible alternatives. A point inside the PP (between the origin and PP) is worse than at least one point on the boundary. For example, point A is feasible but is worse than point D because leisure hours can be increased by moving from A to D without decreasing income. Similarly, point B is better than point A by the same argument.

The prefences of the consumer are represented by the indifference curves (IC's). The indifference curve in Figure 1, is from a family of curves that span from the region bounded by consulting income and leisure axes. Techniques from multi-attribute analysis will be used to determine the indifference curve.

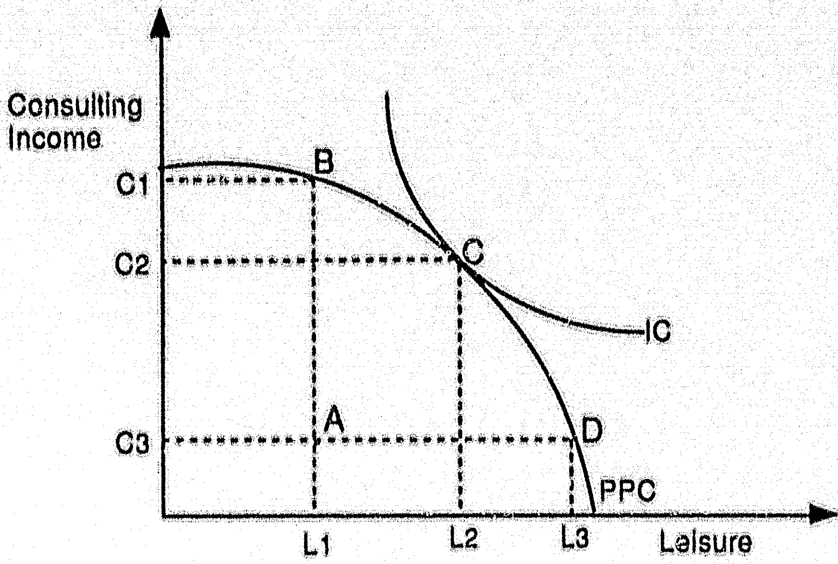

Figure 1. **Graphical Representation of Multi-objective Analysis**

2.2 Derivation of the Optimal Solution.

According to traditional theory, consumers maximise a utility function of the form

(1) $U = U(y_1, y_2, y_3, y_4 \ldots\ldots, y_n)$

subject to the resource constraint

(2) $$\sum_{t=1}^{\infty} p_t y_t = I = W + V$$

where y_t are goods purchased in the market, p_t are their prices, I is money income, W is earnings and V is other income. The point of departure here is the inclusion of leisure time in the analysis.

Virtually all the early labour and recreation demand literature assumes that the value of an individual's time in an activity is at maximum equal to his or her wage rate if working full-time, some fraction of wage rate if working part-time or at minimum, zero if not working at all (Mc Connell 1975). The assumption that time is related to wages was made because static optimization implies that the marginal rate of substitution (MRS) between labour and leisure is equal to the wage rate. This relationship was derived from the conventional supply model, where utility (U) is a function of consumption goods (C) and leisure (L). Utility is maximized subject to the constraint for income (Y) and expenditures (E), and a separate constraint for the maximum amount of time available during some given period.

The model can be presented via the lagrangian (£)

(3) $$£ = U(C, L) + u(wH + V - P_c C) + \lambda(T - H - L)$$

where w refers to the market wage, H is the number of hours worked, V is the total unearned income, Pc is the price of composite consumption goods, and T is the total time available during the same period.

The solution of the lagrangian in equation (3) yields the result:

(4) $$U_C/U_L = u(P_C/\lambda)$$

(5) $$w = \lambda/u$$

where λ is the shadow price of time and u is the shadow price of income. Although most economists recognize that equation (5) implies that the value of leisure time for the individual is his or her market wage, only a few seem to emphasize that the equation also implies that a high marginal utility of ,ncome , other things being equal, denotes a low value of leisure time in some activity. This is one argument cited by Shaw (1992), to explain why he believes that the value of an individual's time spent on leisure is not equal to his or her wage rate.

Johnson (1966) modified the basic labour supply model to show that if the time spent on work is allowed to enter the utility function directly the basic result changes and equation (5) becomes

$$(6) \qquad w = \lambda / u \, U_h / u$$

so that the opportunity cost of time must be adjusted for the increment or decrement to utility (in monetary units) from a marginal increase in work time.

In order to illustrate a situation pertaining to more than two activities, work and leisure, the household production model developed by Becker (1965) will be used. The household production model assumes that individuals uses time (T_i) (a vector) and goods (X_i) to produce "commodities" (Z_i). The individuals's utility is then a function of Z_i rather than the goods themselves, such as:

$$(7) \qquad U = U \, (Z_1 , \ldots\ldots\ldots\ldots , Z_m)$$

where the m commodities are generally produced by the households as

$$(8) \qquad Z_i = f_i \, (X_i , T_i).$$

Solution to the maximization of equation (7) subject to equation (8) and a money and time constraint will yield first order conditions calling for an equalization of "marginal utility products " which are tangencies between an indifference surface and production possibilities frontier (Becker 1965, Smith, Desvouges and Mc Givney 1983).

3. METHOD

This study applies a theory of consumer behaviour, designed to handle valuation of leisure time. Over the years there has been a number of attemps to quantify the value of leisure but those studies were more concerened with specific problems such as the decision to work more or fewer hours (Bruce 1964), the effect of forgone earnings upon consumer choice (Becker 1965), and the valuation of travel time

(Johnson 1966 and Oort 1969). In 1972, Nordhaus and Tobin attempted to impute the value leisure for the United States, based on the assumption that leisure is a commodity like bread and cheese. One of their imputations was based on the assumption that the productivity per hour of leisure increases from one year to the other in proportion to the increase in real wage. In this study, multiobjective utility analysis will be used to determine the utility function specified in equatio.. (1). The theory of multiobjective analysis was presented in the previous section. Traditionally, economic studies have used a single objective for economic analysis such as maximization of income. However, the development of techniques of system analysis, and a systematic approach to multiobjective problems,have become available.

The total utility function will be determined, and indifference curves will then be derived from it. By far the most commonly used consumer trade-off is the indifference approach. It is particularly useful because it divides the set of all attribute values into (a) those indifferent to the reference point, (b) those preferred to the reference point, and (c) those to which the refence point is preferred. These three distinctions are helpful in determining optional points.

When the indifference curves have been specified, the next step is to specify the production possibility frontier. The production possibility curvewill be discussed in section 4.3. Finally, the last step calls for the derivation of the optimal solution.

4. DATA COLLECTION AND RESULTS

The collection of data and the results from the multi-objective analysis will be discussed first, followed by a description of the elicitation of the production possibility frontier. Then the optimal solutions will then be derived.

4.1. Multi-objective Analysis

The consumer's indifference curve can be elicited through the application of the game theoretic models, as a kind of multi-objective analysis. Four relevant objectives were specified with the subject. The first objective is the maximisation of income from the main employer (X_1), this is measured in dollars per year. The second objective is the maximisation of consulting income (X_2) , and this again is measured in dollars per year. The third objective is identified as time spent in paper and article writing (X_3) and this is measured in days per year. The last objective is the maximisation of leisure time (X_4) , measured in days per ye r.

The respondent has identified three objectives which conflict (X_2, X_3, X_4) because an increase in time spent in one would lead to a lesser time spent on another. The approporiate objective function is the expected utility value of the four objectives specified.

The following steps were undertaken to evaluate the utility function:

(a) assessing the univariate utility functions,
(b) determining the independence relationships among the different attributes, and functional form of the utility function, and
(c) assessing the scaling factors (weights) of each of the attributes in the over-all utility function.

The univariate utility function for each objective was assessed by using the Certainty Equivalent procedure with fifty-fifty lotteries. The summary of the five-point utility function is reported in Appendix A. The values of X_i and X_i in Appendix A are not necessarily the worst and the best possible values of X_i. The values represent estimates of the extreme outcomes. Figures 2a to 2d shows that there exists a positive linear relationship between each of the objectives and its level of utility. Equations for the utility functions are specified as follows:

(10a) $$U_1(X_1) = -6.3829 + 0.000098\,X_1$$
$$(16.37)^{***} \qquad R^2 = .9889$$

(10b) $$U_2(X_2) = -0.6731 + 0.000067\,X_2$$
$$(37.00)^{***} \qquad R^2 = .9978$$

(10c) $U_3(X_3) = 0.0000 + 0.009615\, X_3$
$(1.0E+20)^{***}$ $R^2 = 1.0000$

(10d) $U_4(X_4) = 0.0012 + 0.006512\, X_4$
$(35.82)^{***}$ $R^2 = .9977$

where the *** indicates significance at one (1) per cent or better.

The minimum and maximum levels of the four objectives, those elicited in the interview and those computed from the utility f.mction, are reported in Appendix B. Since the feasibility ranges of X_1, X_2, X_3, and X_4 do not differ much to the estimated ones, there was no need to adjust the original utility tunctions. If the estimated value differs from the elicited values , the original utility functions would have to be recalculated to capture the discripancy. In some cases, the difference in value might be due to failure to include some objectives relevant to a certain sector or misspecification of utility function. The linear functions (equations 10a to 10d) show that the respondent exhibit risk neutrality with regards to the four attributes specified.

The three tests of on the form of the utility function were undertaken, preferentX_i ial independence, utility independence and additive independence. Based on the interview with the respondent, it was found that an *additive utility* function is the appropriate form to represent the prefence structure of the respondent. The procedure used (Appendix C) was to check first for preferential independence between X_2X_i and X_{2i}, where i = 1, 3, and 4 and X_{2i} are all the couples not containing X_2 or X_i. A set of attributes (x_i, x_j) is said to be preferentially independent of its complement x_{ij} if the conditional preference order for the consequences with variations in the levels of the attributes (x_i, x_j) does not depend on the levels of other attributes x_{ij} which are held fixed. In other words, it was found that trade-off ratios among the different values of the objectives can be assessed independently of all the other attribute levels. In this study, it was found that there exist preferential independence between X_2X_1 and X_3X_4 ; X_2X_3 and X_1X_4; and X_2X_4 and X_1X_3.

After preferential independence had been established, a test on utility

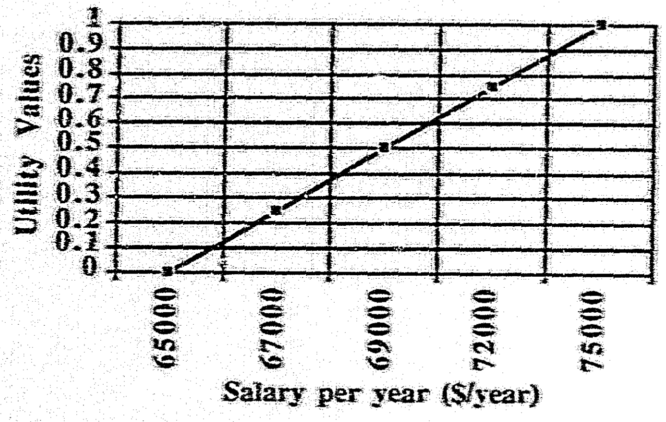

Figure 2a: Five-point Utility Function of X_1

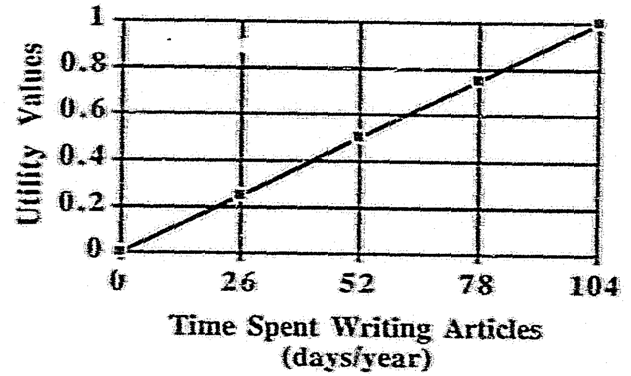

Figure 2c. Five-point Utility Function of X_3

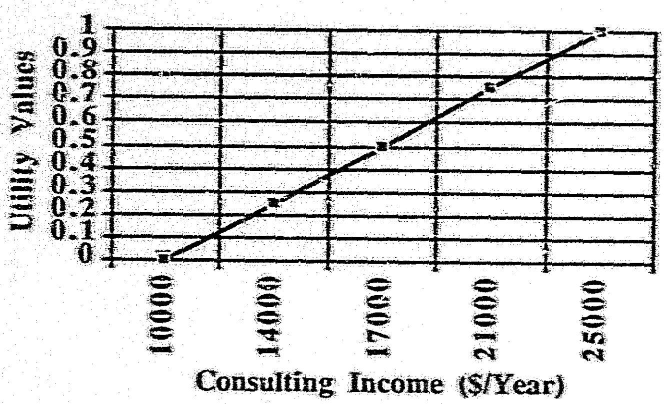

Figure 2b. Five-point Utility Function of X_2

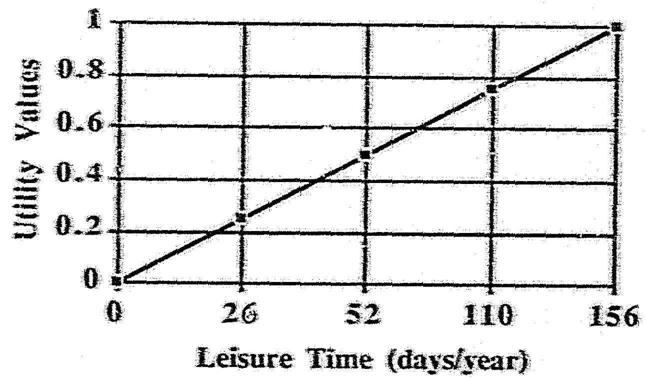

Figure 2d. Five-point Utility Function of X_4

independence was performed. We say that X_2 is utility independent of X_1 when conditional preferences for lotteries, on X_1 given X_2 do not depend on the particular level of X_2. It found that X_2 is utility independent of X_1,X_3 and X_4 . This also means that the four objectives X_1, X_2, X_3 and X_4 are mutually utility independent.

The last check with regard to the functional form of the utility function was for additive independence. It was found that additive independence held for the respondent, that is respondent would prefer to be successful in one objective and to fail in another rather than fail in both.

Now that all three kinds of independence had been established, the scaling constants could be calculated. From the five point utility function in Appendix A and the scalling constant procedure in Appendix D, we get k_1 = **0.29356** k_2 = **0.40000**, k_3 =**0.13276** and k_4 =**0.18636**. Since the sum of the scaling contants is **1.01**, the additive utility function of the following form is justified

(11) $$U(X_i) = \sum_{i=1}^{4} k_i \; u_i \; (X_t)$$

where k_i, i=1,2,3 and 4 are scalling constants and u_i (X_i) are the functions specified in equations (10a) to (10d). Thus the function of equation (11) is written as

(12) $$U(X_1,X_2,X_3,X_4) = \{ [0.29356\, u_1 (x_1)] + [0.40000\, u_2 (x_2)] + [0.13276\, u_3 (x_3)] + [0.18636\, u_4 (x_4)] \}$$

$$= \{ [0.29356 (-6.3829 + 0.000098\, X_1)] + [0.40000 (-0.6731 + 0.000067\, X_2)] + [0.13276 (0.0000 + 0.009615\, X_3)] + [0.18636 (0.0012 + 0.006512\, X_4)] \}$$

The scaling constants are, in fact,weights between objectives. Based on the computed constants, we can say that the respondent rates objective 2 (consulting income) the highest and objective 3 (paper and article writing) the least.

4.2 Indifference Curve

The indifference curves were determined using the utility function of equation (12). To determine the trade-off between consulting income and leisure, X_1 was set equal to the base level of \$65,000 per year and X_3 was set equal to a given level of 52 days per year. The respondent recieves \$65,000 from the university and on the average spends 52 days per year writing papers and journal articles. By substituting \$65,000 and 52 in equation (12), we get

(13a) $$U(X_1, X_2, X_3, X_4) = (-0.00294) + (-0.26924 + 0.0000268X_2) + (0.06638) + (0.00022 + 0.00121\,X_4)$$

$$= -0.265322 + 0.0000268X_2 + 0.00121X_4$$

Expressing equation (13a) in terms of X_2 we get

(13b) $$X_2 = 9900.00 + 37{,}313.43\,U - 45.15\,X_4$$

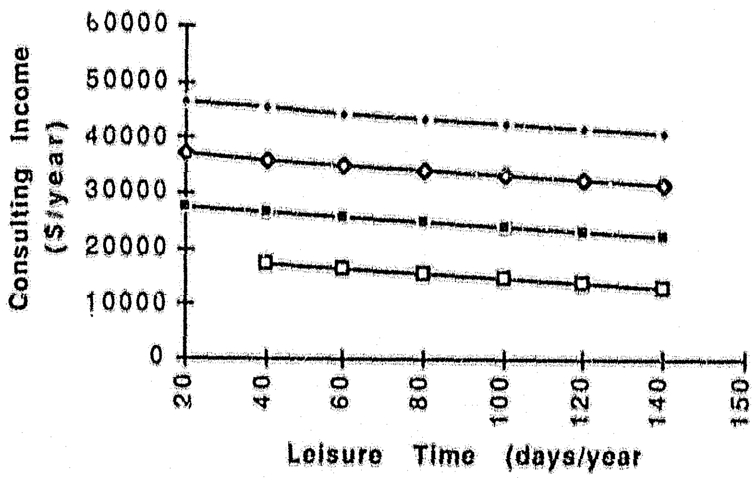

Figure 3a: A Family of Computed Indifference Curves (Multi-objective Analysis)

The indifference curves drawn from this function is given in Figure 3a. The points on the indifference curves were then checked visually against the values elicited from the interview with the respondent. Since the nature of the indifference curves in Figure 3a is the same as that of Figure 3b, the computed indifference curve given in equation (13b) will be used in finding the optimal solution.

The curves of Figure 3b can be expressed as

(14a) $$U = 0.3227 + \underset{(6.5086)}{0.000912\, X_4} + \underset{(15.5612)}{0.0000489\, X_2}$$

Figure 3b was obtained by fixing one attribute at a time following the diamond procedure for obtaining indifference curves. The purpose of Figure 3b is to check the consistency of the respondents answers. Likewise, equation (14a) can be expressed as

(14b) $$X_2 = 6592.80 + 20432U - 18.63\, X_4$$

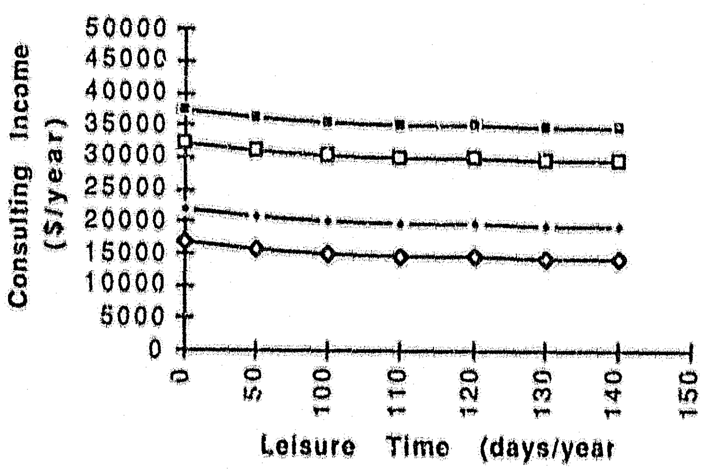

Figure 3b: A Family of Elicited Indifference Curves

4.3 Production Possibility Curve

The curve defines how time can be efficiently allocated between consulting income and leisure. The curve (PPC) was derived by asking the respondent to define (or estimate) the production possibilities for X_2 against X_4.

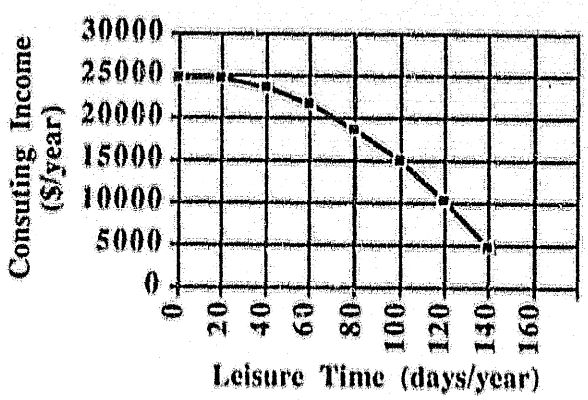

Figure 4 Production Possibility Curve

Figure 4 is the production possibility curve (PPC) of the respondent. The PPC of the respondent is specified as:

(16) $$X_2 = 24898 + 13.574X_4 - 1.1184X_4$$

(153.66) (3.00) (40.94) $R^2 = 0.56$

Equation (16) will be used in solving the optimal solution. Variable X_2 is the dependent variable in the above equation because according to the respondent X_2 can be chosen, it varies according to what the respondent wants.

3.5 The Optimal Solution

Figure 5 is a graphical representation of the multi-objective analysis.The optimal solution is represented by point A, where the indifference curve is tangent to the curve. The optimal solution was derived mathematically by equating the marginal rate of substitution (MRS) to marginal rate of transformation (MRT). MRS is the change in consu[illegible]g income (ΔCI) due to a one hour change in leisure(ΔL), while MRT is defi[illegible]d as an increase in consulting income (ΔCI)

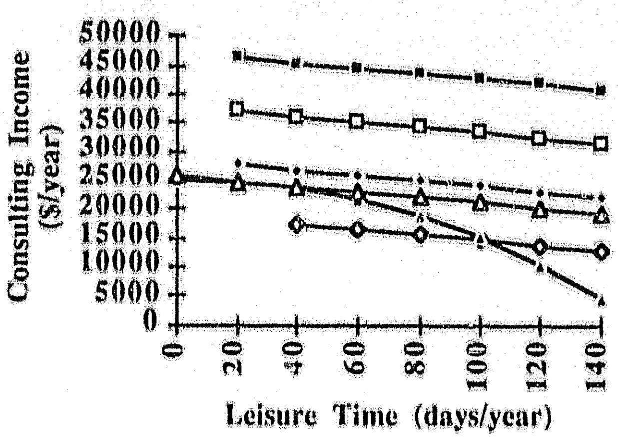

Figure 5. The Optimal Solution

when leisure hours is decreased by one hour (ΔL). The MRS is measured by the movement along the same IC while MRT is measured along the same trade-off function. The computations are as follows:

((16) $MRS_{X_2X_4} = -(\Delta X_2 / \Delta X_4) = -45.15$

The MRS value of -45.15 means that for every one hour decrease in leisure, $ 45.15 of consulting income must be gained to maintain the same level of utility

The MRT is computed to be equal to

(17) $$MRT\ X_2\ X_4 = \Delta X_2 / \Delta X_4 = 13.574 - 2.2368\ X_4$$

Thus, the optimal solution was determined to be **26.25** of additional leisure hours and **$24,477.57** of consulting income.

4. ACCOUNTING FOR LEISURE

For most people a certain amount of leisure is desirable. When people take more of it, less working time is devoted to producing goods and services. This means GDP will be smaller than it otherwise might be. However, this increase in leisure must add to people's sense of well being more than enough to offset the forgone output, or else people wouldn't have chosen to take it. Therefore it would be completely misleading to interpret the reduction in GDP that results from increased leisure as a reduction in society's well being. For example , the length of the average workweek has been roughly cut into half over the last century (Waud 1990). Workers have chosen to take more leisure and as a result GDP is not as large as it would be if workers put in as many work hours as they typically did a hundred years ago. However, it would be erroneous to conclude that society is worse off because GDP is not as large as it could be. Why? Because more leisure has been chosen in preference to additional output. Inclusion of the correct value of leisure time into the GDP computations will show that in fact GDP has been increasing even when the length of average workweek has been decreasing.

Based on Figure 6 we note that the current GNP computations will value the reaspondent's income to be

GNP = $24,477.57

Following Nordhaus and Tobin (1972), Natural Resurce Accounting will value the respondent's contribution to total output to be equal to $24,477.57 The computations

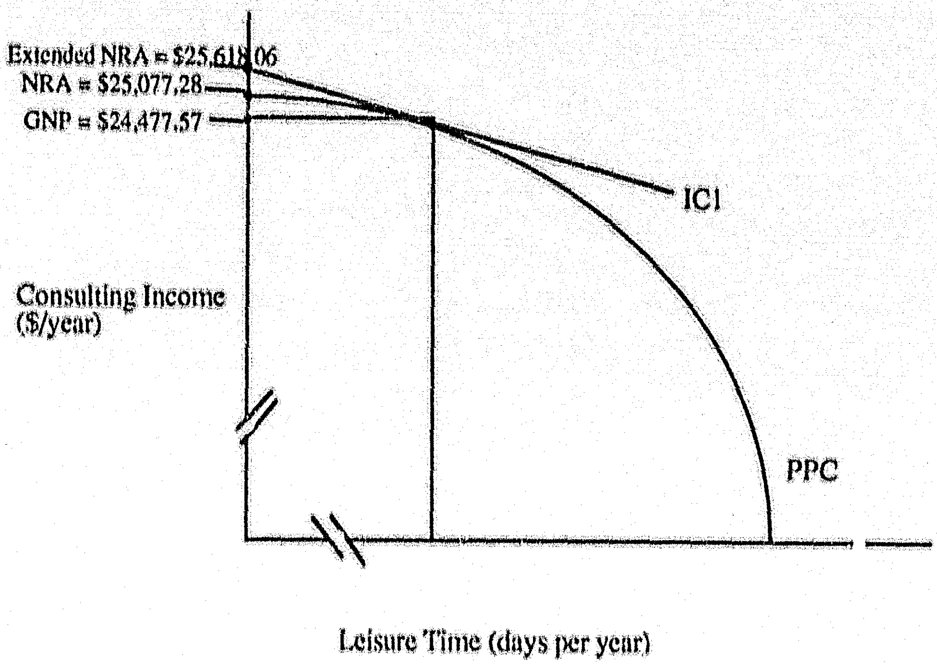

Figure 6. Comparison of Leisure Computations

are as follows:

NRA = GNP + (AVERAGE WAGE) (L)
= $24,477.47 + ($22.85) (26.25)
= $24,477.47 + 599.81
= $ 25,077.28

In the extended model proposed in this study, leisure should be valued as the marginal loss in consulting income. The computations used are as follows:

EXTENTED NRA = GNP + (MARGINAL WAGE) (L)
= \$24,477.57+ (\$45.15) (25.26)
= \$24,477.57 + 1140.49
=**\$25,618.06**

This tells us that the marginal wage method should be used in imputing for the value of leisure. The average wage method will partly account for the value of leisure but the method will understate the true value of leisure. The results can be summarised as follows:

PERSON 1	PERSON 2
GNP = \$24,477.57	GNP = \$ 29,740.38
NRA = \$25,077.28	NRA = \$ 30,807.76
EXTENDED NRA = \$25,618.06	EXTENDED NRA = \$ 31,500.83

The procedure used to determine the values of the three methods for person 2 is the same as that of person 1. Appendix E shows the detailed computations for person 2. The results for person 2 show that the true marginal wage associated with leisure is higher than the average wage for leisure.

5. CONCLUSIONS AND RECOMMENDATIONS

The results show that the marginal valuation of an hour of leisure was double the average wage per hour for respondent 1 and 2. Thus, using the average method to value leisure will lead to the underestimation of the true value of additional leisure hours to society. The same method can also be used for environmental goods and services. However, it should be noted that there are difficulties in the specification of the production possibility frontier and problems associated with the aggregation for the indifference curves of many respondents. Notwithstanding its limitations, the proposed method can accomodate environmental and natural resource issues in its framework.

REFERENCES

Australian Bureau Of Statistics (1990), Australian National Accounts: National Income And Expenditures, March Quarter, pp. 63-71.

Becker, G. S. (1965), "A Theory of the Allocation of Time ", Economic Journal, Vol. 75, pp. 493-517.

Chankong, V. And Y.Y. Haimes (1983) Multiobjective Decision Making: Theory And Methodology Series, Vol.8, Elsevier Science Publishing Co. Inc. New York

Gilbert, A. And D. James (undated probably 1985) Natural Resource Accounting- A Review Of Current Activity And Its Application To Australia.

Johnson, M.B. (1966), "Travel Time and the Price of Leisure", Western Economic Journal, Vol 4 (Spring), pp. 135-145.

Keeney, R. L. And H. Raiffa (1976), Decisions With Multiple Objectives, Preferences And Value Trade-Offs, Wiley, New York.

Kokoski, M. (1987), "Indices of Household Welfare and the Value of Leisure Time" Review Of Economic Statistics, Vol. 69, pp. 83-89.

Mc. Connell, K. E. (1975), "Some Problems in Estimating the Demand for Outdoor Recreation", American Journal Of Agricultural Economics, Vol.57, pp.330-334.

Nordhaus, W And J. Tobin (1972) "Is Growth Absolete" Discussed in The Measurement Of Economic Growth (1980), D. Usher (Ed) , Basil Blackwell Oxford.

Oort, C.J. (1969), " The Valuation of Travelling Time", Journal Of Transport Economics And Policy (September).

Repetto, R. et al (1989), Wasting Assets, Natural Resources In The National Income Accounts, World Resources Institute.

Smith,V. K. , W.H. Desvouges And M.P. Mc Givney (1983), "The Opportunity Cost of Travel Time in Recreation Demand Models" Land Economics, Vol.59, pp. 259-277.

Solorzano, R. et al (1991), Accounts Overdue: Natural Resource Depreciation In Costa Rica, World Resources Institute And Tropical Science Center , Costa Rica.

Thampapillai, D.J. (1983) "Trade-Offs for Conflicting Social Objectives in the Extraction of Finite Energy Resources", Energy Research, Vol. 9, pp. 179-192.

Zeleny, M. (1988), Multicriteria Decision Making: Quantitative Methods For Management Series, Mc Graw Hill Book Company, New York.

Appendix A

Five Point Univariate Utility

Variable Name	Utility Values				
	0.00	0.25	0.50	0.75	1.00
X_1 (Salary from major employer in $ per year)	65,000	67,000	69,000	72,000	75,000
X_2 (Consulting Income in $ per year)	10,000	14,000	17,000	21,000	25,000
X_3 (Paper and Article Writing in days per year)	0	26	52	78	104
X_4 (Leisure time in days per year)	0	26	52	110	156

Appendix B:

Estimated and Actual Minimum and Maximum
Levels of the Four Attributes of the Objective Function

Variable Name	MINIMUM Elicited in Interview	VALUE Calculated	MAXIMUM Elicited in Interview	VALUE Calculated
X_1 (salary from main employer in $/year)	$65,000	$64,591	$75,000	$74,711
X_2 (consulting income in $/year)	$10,000	$9,984	$25,000	$24,816
X_3 (paper and article writing in days per year)	0 days	0 days	104 days	104 days
X_4 (leisure time in days per year)	0 days	-0.2 days	156 days	153.4 days

Appendix C

Preferential Independence and Utility Independence Test

C1. Preferential Independence (PI)

Q. Which would you prefer, S_1 or S_2?

$$S_1 = \begin{cases} X_1 = \$65{,}000 \\ X_2 = \$10{,}000 \\ X_3 = 104 \text{ days} \\ X_4 = 156 \text{ days} \end{cases} \qquad S_2 = \begin{cases} X_1 = \$65{,}000 \\ X_2 = \$25{,}000 \\ X_3 = 104 \text{ days} \\ X_4 = 52 \text{ days} \end{cases}$$

Answer: $S_1 > S_2$

Q. Which would you prefer, S_3 or S_4?

$$S_3 = \begin{cases} X_1 = \$75{,}00 \\ X_2 = \$10{,}00 \\ X_3 = 52 \text{ days} \\ X_4 = 156 \text{ days} \end{cases} \qquad S_4 = \begin{cases} X_1 = \$75{,}000 \\ X_2 = \$25{,}000 \\ X_3 = 52 \text{ days} \\ X_4 = 52 \text{ days} \end{cases}$$

Answer: $S_3 > S_4$

Q. How did the levels of X_1 and X_3 affect your preference?

Answer: X_1 and X_3 have little effect on my preference.

Conclusion: **X_2 X_4 PI of X_1 X_3**

The whole exercise was repeated several times to test other combinations of variables. The results show that:

(i) X_2X_1 PI of X_3X_4

(ii) X_2X_3 PI of X_1X_4

C2 Utility Independence (UI)

Q. What should X_1' be so that you will be indifferent between L_1 and S_{11}?

L_1 → \$65,000 \$10,000 104 days 52 days

L_1 → \$75,000 \$10,000 104 days 52 days

$S_{11} = X_1'$ \$10,000 104 days 52 days

Answer : **\$68,000-\$69,000**

Q. What should X_1'' be so that you'll be indifferent between L_2 and S_{12}?

L_2 → \$65,000 \$25,000 104 days 52days

L_2 → \$75,000 \$25,000 104 days 52 days

$S_2 = X_1''$ \$25,000 104 days 52 days

Answer: **\$69,000**

The procedure was repeated by changing the values of X_3 and X_4.

Q. How would the different levels of (X_2 , X_3 and X_4) affect the level of X_1 decided?

Answer: Not prepared to gamble . The levels of X_2, X_3 and X_4 did not affect the level of X_1.

Conclusion: **X_1 UI of X_2 X_3 X_4**

The same test was conducted for the other variables.

Appendix D.

Computations of Scalling Constants

Q1. What should X_2' be such that (\$75,000 X_2' 104 days 156 days) ~ (\$65,000 \$25,000 104 days 156 days) ?

The symbol ~ means "is indifferent to".

Answer:: X_2' = \$ 21,000

Conclusion : k_2u_2(\$17,000) = k_1

Q2. What should X_2'' be such that (\$65,000 X_2'' 104 days 156 days) ~ (\$65,000 \$25,000 0 days 156 days) ?

Answer: X_2'' = \$15,000

Conclusion: k_2 u_2 (\$15,000) = k_3

Q3: What should X_2''' be such that (\$65,000 X_2''' 104 days 156 days) ~ (\$65,000 \$25,000 104days 0 days)?

Answer: X_2''' = \$17,000

Conclusion: k_2 u_2(\$21,000) = k_4

What should P_1 be such that

$75,000 $25,000 0days 0days

$65,000 $10,000 104 days 156 days

~ $75,000 $25,000 104 days 156days

Answer: **P_1 = 0.40**

Conclusion: **k_2 = 0.40**

From the five-point utility function of X_2 (equation 10b), we know that $U_2(\$17,000)$ = 0.50. By substituting X_2=$15,000 into the continuous utility function of X_2, we get $U_2(\$15,000)$ = 0.4659. Thus we get k_1 = 0.29356, k_2 = 0.400000, k_3 = 0.13276 and k_4 = 0.18636.

Appendix E

Calculations for Respondent 2

The multiobjective analysis was again applied to determine the marginal value of leisure. The five point utility values were determined for X_1 (income) and X_2 (leisure time). Figure 7 shows that the respondent slightly exhibit a risk taker attitude towards X_1. The utility function specified for X_1, however, is linear. Figure 2 on the other hand shows that the respondent has a risk averse attitude towards X_2, thus a quadratic equation was specified for X_2.

The optimal solution was determined to be 102.83 hours of leisure per year and $29,740.38 of income per year. The results also show that the true marginal wage associated with leisure is higher than the average wage for leisure.

E1 Five-point Univariate Utility

	Utility Values				
Variable Name	0.00	0.25	0.50	0.75	1.00
X_1 (salary in $ per year)	0	12500	22000	26500	30000
X_2 (Leisure time in hours per year)	0	260	650	1120	1800

RESPONDENT 2

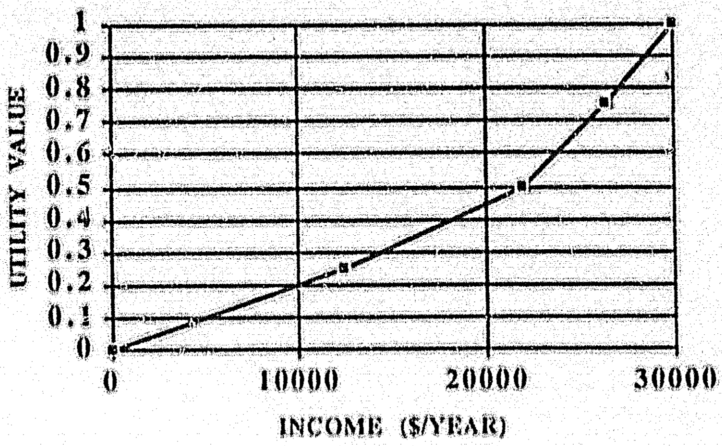

Figure 1. Univariate Utility Function of X_1

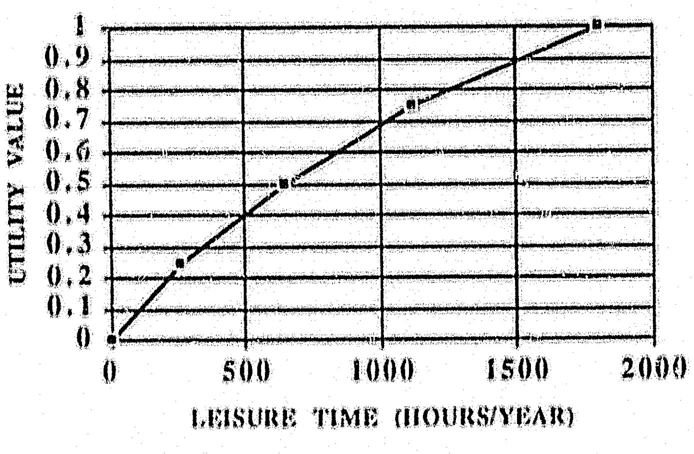

Figure 2. Univariate Utility Function of X_2

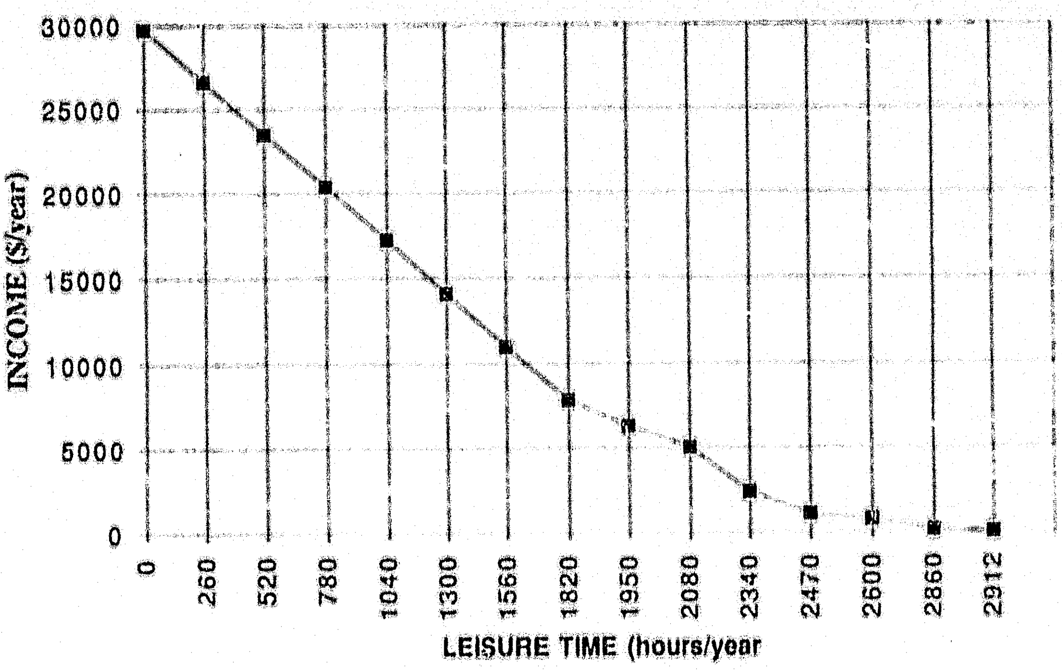

Figure 3: The Production Possibility Frontier

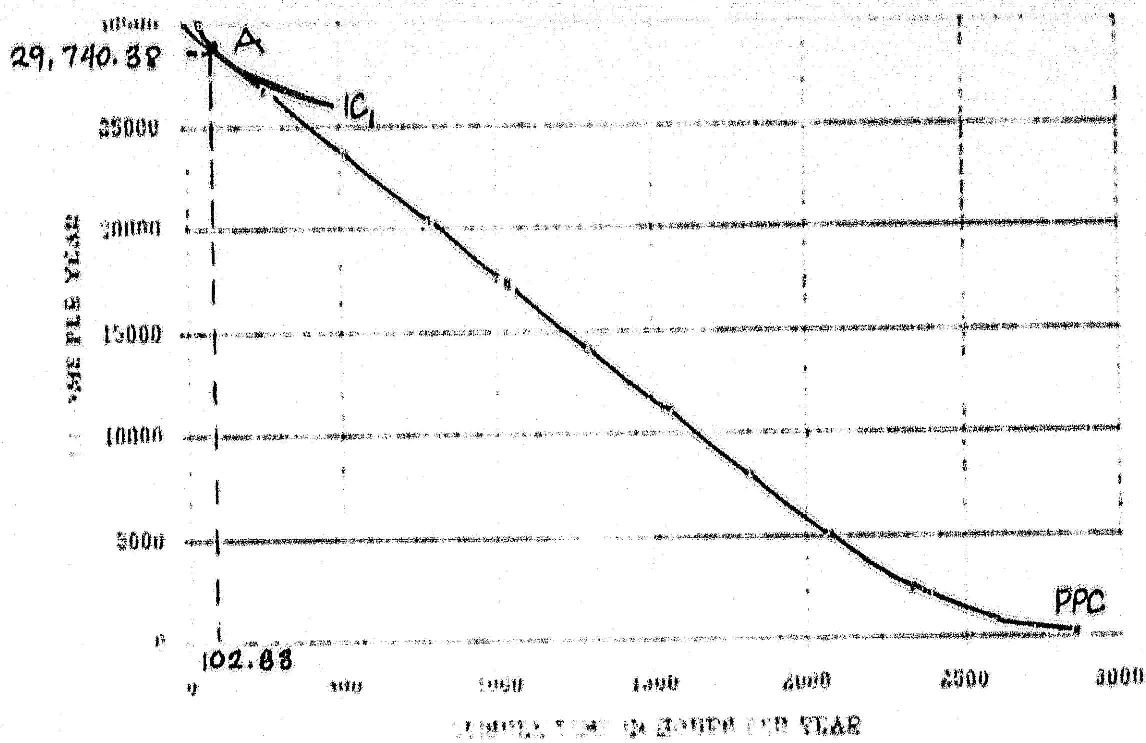

Figure 4: The Optimal Solution

E2 Estimated and Actual Minimum and Maximum Levels of the Two Attributes of the Objective Function

	Minimum Value		Maximum Value	
Variable Name	Elicited in Interview	Calculated	Elicited in Interview	Calculated
X_1 (salary in $ per year)	0	0	30000	31194
X_2 (Leisure time in hours per year)	0	0.71612	1800	1900

E3 Summary of Functions

(1) Production Function

$$X_1 = 30506 - 14.89\,X_2 + 0.072396\,X_2 \qquad R^2 = 0.9955$$
$$(18.30) \qquad (5.32)$$

(2) Univariate Utility Functions

$$U_1(X_1) = 0\ 02695 + 0.0000000010054\,X_1 \qquad R^2 = 0.9898$$
$$(17.031)$$

$$U_2(X_2) = 0.014495 + 0.0008646\,X_2 - 0.00000018\,X_2^2 \qquad R^2 = 0.9906$$
$$(16.793) \qquad (6.491)$$

(3) Total Utility Function

$$U(X_1X_2) = 0.70(U_1X_1) + 0.3(U_2X_2)$$

$$U(X_1X_2) = \{0.70\,(0.02695 + 0.0000000010054\,X_1) + 0.30\,(0.014495 + 0.0008646X2 - 0.00000018\,X_2^2)\}$$

$$= \{0.018865 + 0.00000000070378\,X_1 + 0.0043485 + 0.00025938\,X_2 - .000000054\,X_2^2\}$$

$$= \{0.0232135 + 0.00000000070378\,X_1 + 0.00025938\,X_2 + 0.000000054\,X_2^2\}$$

(4) Indifference Curve Function

$$0.00000000070378\,X_1 = \{-0.0232135 + U(X_1X_2) - 0.00025938\,X_2 - 0.000000054\,X_2\}$$

$$X_1 = \{-33{,}162{,}143 + 1{,}428{,}571{,}429\,U(X_1X_2) - 370{,}543\,X_2 - 77X_2\}$$

$$X_1 = \{-5758.65 + 608.72\,X^{1/2} + 8.78\,X_2 + 37796\,U(X_1X_2)\}$$

E4 Comparison of the Three Methods

GNP = $ 29,740.38

NRA = GNP + (AVERAGE WAGE)(L)
= $ 29,740.38 + ($ 10.38)(102.83)
= $ 29,740.38 + 1,067.38
= $30,807.76

Extended
NRA = GNP + (MARGINAL WAGE)(L)
= $ 29,740.38 + ($ 17.12)(102.83)
= $ 29,740.38 + 1,760.45
= $ 31,500.83