THE ALLOCATION OF TIME

AND THE THEORY OF

CHOICE ON LABOUR MARKETS
any policy or position of the Department of Manpower and Immigration are solely those of the author, and do not necessarily correspond to Manpower Requirements Division, Research Branch. The views expressed rest in the summer of 1972, under the direction of K. F. Scott, Department of Manpower and Immigration, during the summer of 1971.

The study, "Choice on Labour Markets and the Theory of the Allocation of Time," was written by Walter E. Stewart, Ph.D., as part of the completion of a博士。
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of consumer preferences from market data are much more difficult than the

Secondly, the econometric problems associated with the estimation

service during each period of time.

To assuming that the consumer is capable of offering only one type of labour
the price of time is uniquely determined in any given period which is equivalent
of the labour supply decision as a special case (5. 502) which contains the standard analysis
the theory of the allocation of time (5) which contains the standard analysis

consumer can offer only one type of labour service. Similarly, Becker’s
a supply decision in the context of consumer theory that the
labour service (has not been developed. The standard analysis of the labour
with consumer-workers who are capable of offering many different types of
First, the theoretical framework (which would enable us to deal
There are at least three reasons for this lack of empirical work.

labour on a disaggregated basis, we find virtually no empirical studies.

However, when we turn to the problem of modelling the supply of

case of the more general production function approach (2

determined by which the manpower requirements approach (1 which is a special
The demand for labour services of various characteristics may be

for manpower and (1) the supply of manpower.

The economics of manpower planning has two aspects: (1) the demand

I. Introduction

M. E. Drever

Theory of the Allocation of Time

Critical On Labour Markets And
that wages and prices are fixed. We will consider these problems in section 5. Thus we will have to modify the traditional consumer theory which assumes take-home wage rate will be a function of the number of hours he works and however, note that whenever we have a progressive taxation scheme, a worker's performance is in the analysis of anti-poverty taxation schemes.

Another context where it would be useful to estimate consumer.

In educational expenditure, could use the model to simulate the effects on relative wages of changes exogenous variables are education and job training programs, and thus we on the forecasts of the various exogenous variables. Two of the important functions would be very useful in many contexts; for example, for constrained a complete system of disaggregated labor supply and demand. Techniques provided that the requisite data were available, indicate how consumer-worker preferences could be estimated by economic.

Now consider the labor market. An essential step in our analysis is the derivation of labor supply decision when the consumer has the restricted framework for the labor supply decision. The main purpose of the present paper is to (1) provide a

exist in any great abundance.

The final reason for the paucity of empirical work in the area is not observable even in principle.

The counterpart to output in the context of consumer theory, utility, are in principle observable quantities in the context of production theory. Problems involved in estimating production functions, outputs and inputs...
is algebraically obtained. The unknown parameters in the utility function are unknown. The unknown parameters in the consumer's system of derived demand functions is the problem (which is the consumer's budget constraint and the solution)
maximized subject to the consumer's budget constraint and the solution
on a small number of unknown parameters. The utility function is then assumed a functional form for the consumer's utility function which depends on the "mean" preferences of a representative homogeneous group of consumers. This is the usual econometric method of estimating a consumer's preferences or the usual econometric method from the traditional economic point of view. The

In section 4, we consider the problem of estimating consumer ...

and then certain prices (and income) are now allowed to become negative. over the analysis of previous (1) are that the choice set is more general
based on the work of Aitken (1). The main innovations in this section is the results of the test are favorable. The analysis in this section is an approximation to the consumer's true utility function, where the
utility maximization. The results of the test may be used to construct whether a given consumer-worker's market choices are consistent with market ...

In section 5, we present a simple test which will determine on the nonwork allocation of time are not available.

framework which is more readily econometrically estimated if detailed data we introduce how the generalized Becker model may be transformed into a type of labor service. We also discuss the problems which arise when and cases where the consumer-worker is qualified to offer more than one of nonconstant returns to scale in production, cases of joint production allocation of time (5), and we generalize this framework to include cases allocation of time (9).

In section 2, we give a brief outline of Becker's theory of the
spend time in the labour force working for someone else. In a later article,
household work such as cooking, washing, mowing the lawn, etc.; (iii) time
spent doing household chores (including goods (testing); (iv) time spent doing
household behavior which divides household time into three broad categories:

female labor force participation rate may be partitioned by a model of
more recently, Whaler (1970) has shown how the secular increase in the
change in the wage rate on labor supply was theoretically understandable.

the contributions to the study of

Kleiber (1967), who introduced indifference curve analysis to the study of

Waters (1970). Other important theoretical contributions were made by
activities in the context of utility theory was introduced by Jevons (1871) and
the analysis of the allocation of time between work and non-work

2. Becker's theory of the allocation of time revealed

in Table 12.

analyzes is strict in the sense that we have made no allowance for changes
in the temporary allocation of labor and wealth are ignored and (iii) the
problems involved in the part-
(1) problems arising because of uncertainty, or ignorance of the part-
before proceeding, we must note some limitations of our analysis:

labor force participation decision.

In particular, we indicate how the analysis may be extended to the family
In section 6, we note some further extensions of the analyses;

which gives utility as a function of prices and income.

difficulties by making use of the concept of the indirect utility function.

impossible, however, we shall show how to circumvent these algebraic
form for the utility function, then the derived demand functions become
with this approach is that it we start with a reasonable general functional

some form of regression analysis. The only problem

reappear in the derived demand functions and are then estimated by
\[ H = \sum_{j} \frac{u_j}{u_j} (\frac{I_j}{N_j}) \]

subject to

Maximize \[ u_{\text{market goods, } C} \]

where

- \( H \) is the number of hours the period under consideration has,
- \( L \) is the number of hours of labour the consumer offers during the period under consideration,
- \( L \) is the number of hours of labour the consumer offers in the labour market,
- \( w \) is the hourly wage rate which the consumer can earn at the one type of employment considered,
- \( \Lambda \) is the consumer's non-labour income which he spends during the period under consideration,
- \( u_{\text{market goods, } C} \) is the utility of market goods, \( C \) and time, \( T \),
- \( u_{\text{market goods, } C} \) is the consumer's utility function.

Miner (20) indicated how various demand elasticities (such as the demand elasticity for air travel or for children) could be biased because the

Miner's basic framework has been extended in a variety of ways by Becker (5) and Down (4).
2.2

Maximize 

subject to

where 

The results of these substitutions may be summarized by the following constraints: 1. In order to eliminate L from the budget constraint (11), the algebraic constraints of household technology. We may also use the time constraint. 

A utility function of the parameters of the old preference function and the new utility function. Thus, the new utility function of the production relations (1) into the utility function: that is, define the production function. We can eliminate the unobservable variables Z by substituting the

will also hold with equality (11)

the consumer is never satisfied with goods, then the budget constraint (11)

amount of time doing something (unless the consumer is) spent, that

an equality since in any given period of time, the consumer must "spend" that

than his available income but the time constraint (11) is written with

with an inequality since the consumer always has the option to spend less

consumer’s time constraint (11). The budget constraint (11) is written as the

to the technological constraints (11); the budget constraint (11) and the

supply function are determined by maximizing his utility function, subject to

system of consumer demand functions, demand for time functions and labor.

preferences may be represented by some utility function. The consumer's

preferences defined over combinations of basic commodities (which are

The basic idea of the above model is that the consumer has
would enable us to deal with the consumer-worker's occupational choice decision.

offering many different types of labor service, we need a model which
during any given time interval, as a typical worker is generally capable of
capable of offering a wide variety of different types of labor service.
offer only one type of (occupational)
labour service, and thus this model is unable to deal with the worker who
of time, the consumer-worker is qualified to offer only one type of (occupational)

Note that Becker's model implicitly assumes that in any period
the unknown parameters of the consumer's utility function $U^0$
this system of derived demand equations could be used in order to estimate,
and in theory, functions $N_{L}^0$, $N_{L}^1$, $N_{L}^2$, $N_{L}^3$, $N_{L}^4$, $N_{L}^5$, $N_{L}^6$, $N_{L}^7$, $N_{L}^8$
the consumer-worker's system of derived consumption functions, $C_{L}^0$, $C_{L}^1$, $C_{L}^2$, $C_{L}^3$, $C_{L}^4$, $C_{L}^5$, $C_{L}^6$, $C_{L}^7$, $C_{L}^8$
while the time constraint $Z_{t}$ holds with an inequality, we will obtain
the assumption that constraint $Z_{t}$ holds with an equality

Thus if we assume a functional form for $U$, and solve the maximization

$$U^0 = \sum_{t=1}^{T} \left( H - \frac{u}{N} \right)$$

By:

if written with an inequality since the labour supply function is defined
activities should not exceed his full income. The time constraint $Z_{t}$
time on consumer goods plus the value of his expenditures on time in consumption
the budget constraint $Z_{t}$ says that the value of the consumer's expenditure-

Thus, the consumer's labour income which is spent during the period plus the

Becker calls $V+M$ (which is equal to the value of the con-
consumer-worker to have specific preferences with respect to the different
innovation over the model represented by 2.2 consists in allowing the
preferences with the parameters of household production functions.

The utility function of 2.4 again combines the parameters of

\[ H = \text{the number of hours in the period,} \]

and

\[ W = \text{the absolute value of} \ \Lambda \text{is equal to the amount of labour income,} \]

\[ \Lambda = \text{non-labour income spent during the period (or} \ \Lambda \text{is negative,} \]

\[ \text{on the} \ m \text{household activity,} \]

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The solution to the constrained maximization problem 2.5 is the model as a special case of 2.5.

Consumer can offer only one type of labour service, then we obtain Becker's model 2.2 if K = 1; i.e., if the model reduces to Becker's model 2.2 if K = 1. If the system

\[ \begin{align*}
H & \geq \frac{K}{3} + \frac{w}{3} \frac{I+M}{3} \\
\frac{K}{3} + \frac{w}{3} \frac{I+M}{3} & = \frac{w}{3} \frac{I+M}{3} \\
\frac{c}{2} & \geq \frac{K}{3} + \frac{w}{3} \frac{I+M}{3} \\
\frac{c}{2} & = \frac{K}{3} + \frac{w}{3} \frac{I+M}{3} \\
\frac{c}{2} & \geq \frac{K}{3} + \frac{w}{3} \frac{I+M}{3} \\
\frac{c}{2} & = \frac{K}{3} + \frac{w}{3} \frac{I+M}{3}
\end{align*} \]

subject to

\[ \begin{align*}
0 & \leq L-I, \quad L \geq 0, \\
0 & \leq M, \quad M \geq 0, \\
0 & \leq c, \quad c \geq 0
\end{align*} \]

with one less decision variable.

Problem 2.4 is equivalent to the following constrained maximization problem

\[ \begin{align*}
\text{Maximize} & \quad U(L, M, c) \\
\text{subject to} & \quad 0 \leq L-I, L \geq 0, \\
& \quad 0 \leq M, M \geq 0, \\
& \quad 0 \leq c, c \geq 0
\end{align*} \]

Substitute this latter relation into the utility function and budget constraint, and then to solve for one of the L's (say \( L \)). Since this time the constraints holds with equality, we may use it.

If the consumer's time constraint is not saturated with goods (and 2.4 if so), then (11) is the consumer's time constraint, which will hold with an equality as long as the consumer is not satisfied. To change in relative wages raises to a change in relative wage raises, Becker's model 2.4 is the consumer's.

Types of labour service he is qualified to offer and thus the model is now...
2.6. Define the following derived utility function by:

\[ u(x, y, z) = \max \{ 0, f(x, y, z) \} \]

I call it implementable.

Transform the model given by 2.4 into a form which is more readily compilable. This we must do not collect data on the consumer's allocation of income and wealth. Thus we must do not collect data on the consumer's allocation of time in consumption with

particular consumer-worker.

The occupation is consistently the highest paying occupation for our for some \( k \), and (iii) Income \( \Pi \). Thus \( M - K \) can be negative unless the

price \( M - K \) can be negative (i.e., some prices can be negative) and (ii) have the same

maximization problem. It is much like the standard utility maximization

If the time constraint (iii) is assumed non-binding, then the

determined with his income allocation decision.

Note that the consumer's time allocation decision is simultaneous.

\[ \ldots \left( 1 - K \right) X_{M}, \left( 1 - K \right) N_{d}, \ldots, I_{d} \quad \left( 1 - K \right) X_{M} + \lambda \]

Note that the artificial supply function is defined residually by

In order to estimate the unknown parameters of the utility function \( u \), and they may be used

functions of \( \lambda \) and labor supply
of consumer behavior, which is broad enough to include 2.7 as a special case. 2.7 in the 1870s and more recently, Deboer (1978) has formulated a model economists: Walters (1978) formulated a model which was very similar to the derived utility maximization problem 2.7 is not new to approximation to (1) using market data.

In the remainder of this paper, we will concentrate on the problems involved in estimating the derived utility function $f$ or an

In 2.7 are defined as in 2.4.

2.7 (ii) corresponds to the worker's time constraint. All variables in that 2.7 (i) corresponds to the usual consumer's budget constraint and note that 2.7 (i) also need data on the $I^W$ function $U$, we need to estimate the underlyng utility function $U$. However, in order to estimate the order to estimate economically the derived utility function $f$, we do explicitly appear in the latter maximization problem and therefore in two maximization problems, 2.6 and 2.7. Note that $I^W$ do not

Thus the single utility maximization problem 2.4 has been decomposed

$$\begin{align*}
H_x & \geq I_x^L, \quad x = 1, \ldots, K, \\
A_x & \geq L_x^L, \quad x = 1, \ldots, K, \\
P_x & \geq C_x^L, \quad x = 1, \ldots, N, \\
N_x & \geq 0, \quad x = 1, \ldots, N
\end{align*}$$

subject to

Maximize $f(I^W, C^W, L^W)$

Problem

Now consider the following second stage utility maximization

Thus the function $f$ has absorbed the consumer's allocation of household

optimal $I^W, \ldots, I^W$ into $u$ and call the resulting function $f$ (2.7).

we find the consumer's optimal allocation of time, substitute the corresponding feasible set of labor supplies $L^W, \ldots, L^W$ with

Thus for any given set of combinations $C^W, L^W, K^W, r_i^W$ and any
Another regularity condition which we will impose on the utility function \( f \) is defined by 2.6 is continuous, \( k \). 

Above, we could also show that the derived utility function \( u \) is the upper semicontinuous provided that \( k \). If we now follow from a theorem \( \frac{L}{f} \), is upper semicontinuous, provided that \( k \). It is easy to see that \( k \) is a set valued utility functions are generally called \( \frac{L}{f} \) (see Berge (1976)). 

Next, we note that the set valued function (or correspondence) is closed, bounded, and is attained. (See Berge (1976).) 

defined since the maximum of a continuous function over a bounded set is attained. Thus the function \( f \) is defined by 2.6 is well defined. Provided that \( k \) is a nonempty, closed, bounded set, \( \{ K, L \} \) is a maximum of \( f \). Which we denote by \( (K, L) \) (which are feasible for the max-

**Proof:** First we note that the set of \( L \)s which are feasible for the max-

utility function \( f \) is defined by 2.6 is also continuous from above. 

**Lemma:** If the utility function \( u \) is continuous from above, then the derived utility function \( f \) is continuous from above.

**Following Result:**

Closed and this is a very weak regularity property. Then we have the following result:

assuming that the individual is preferred to itself, \( u \) is continuous from above. This is equivalent to the utility function \( u \) being continuous from above. Let us suppose that the properties of the derived utility function \( f \) are determined.
\begin{align*}
\frac{\partial u}{\partial x} & = \frac{\partial u}{\partial x} \\
\frac{\partial u}{\partial y} & = \frac{\partial u}{\partial y} \\
\frac{\partial u}{\partial z} & = \frac{\partial u}{\partial z}
\end{align*}

Then we have by the definition of

\begin{align*}
\frac{\partial^2 u}{\partial x^2} & = \frac{\partial^2 u}{\partial x^2} \\
\frac{\partial^2 u}{\partial y^2} & = \frac{\partial^2 u}{\partial y^2} \\
\frac{\partial^2 u}{\partial z^2} & = \frac{\partial^2 u}{\partial z^2}
\end{align*}

\begin{align*}
\frac{\partial^2 u}{\partial x \partial y} & = \frac{\partial^2 u}{\partial x \partial y} \\
\frac{\partial^2 u}{\partial x \partial z} & = \frac{\partial^2 u}{\partial x \partial z} \\
\frac{\partial^2 u}{\partial y \partial z} & = \frac{\partial^2 u}{\partial y \partial z}
\end{align*}

\begin{align*}
\frac{\partial^2 u}{\partial y \partial z} & = \frac{\partial^2 u}{\partial y \partial z} \\
\frac{\partial^2 u}{\partial z^2} & = \frac{\partial^2 u}{\partial z^2}
\end{align*}

\text{Definition: } u \text{ exhibits local nonmonotonicity in goods if for every scalar}

\begin{align*}
2.9 & \text{ Lemma: If } u \text{ is a quasi-concave function from above, continuous from above function, then the derived utility function } f \text{ is also quasi-concave.} \\
2.10 & \text{Corollary: If } u \text{ is a quasi-concave function from above, continuous from above function, then the derived utility function } f \text{ is also quasi-concave.}
\end{align*}

\begin{align*}
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\end{align*}
worker's weekly working time. However, as Bronfman and Mossin (8, 324) have pointed out, the worker's spread so that the individual worker can vary his hours continuously.

The possibility of part time work and moonlighting is sufficiently wide.

There are at least two ways of meeting the fixed hours obligation.

(A) Standard work week.

Ordered collectively, workers will be able to vary the number of hours in the course of a week. For example, the consumer may have a choice of working either zero or forty hours per week on a particular job, because of institutional barriers. For instance, the number of hours of labour services of a particular type may be defined as an arbitrary number of hours of labour services of a particular type, so that the fact that some consumer-workers may not be able to choose to

\[ a \cdot d \]

Thus \( a \cdot d \).
Thus we see that the effect of introducing "standard" hours set \( L^{X} \) (n) of the restricted indifference set \( L^{X} \) (n) by the extended, articulated indifference curve. The restricted indifference curve of consumer behavior will be observed if we replace the standard number of hours on Figure 7.2, we see.

From Figure 7.1 that the consumer will maximize his satisfaction by

**Figure 7.1.** The consumer's budget line is drawn through \( L^{X} \) (n), consists of a portion of the \( n \times n \) grid and the shaded region of the set of feasible \( (c, l) \) combinations which yield at least utility level \( n \).

The set of feasible \( (c, l) \) combinations which yield at least utility level \( n \), which yield at least utility level \( n \) to the consumer-worker. However, we assume he can work either zero hours or any number of hours between \( L^{X} \) and \( L^{X} \). In Figure 7.1, \( L^{X} \) (n) represents the set of \( (c, l) \) combinations with \( L^{X} \) on the set \( X^{A} \). An example will make the procedure clear.

The set of feasible \( (c, l) \) combinations that are not preferred to set \( L^{X} \) (n), which are not preferred to set \( L^{X} \) (n), are

\[ \{ x \in X^{A} : (x, y) \in L^{X} \ (n) \} \]

For every utility level \( n \), it is sometimes convenient to expand the restricted indifference or preferred to set \( L^{X} \) (n).

The following section, let \( X^{A} \) be the consumer-worker. We will assume that \( X^{A} \) is a closed subset of \( X^{A} \), and define the following.

Now let \( X \) be the subset of alternatives which are actually open.

\[ \{ x \in X^{A} : (x, y) \in L^{X} \ (n) \} \]
Now let us suppose that we are given a time series (or cross section)

\[ \{ \forall X \in \mathbb{R}^k \} \]

of market prices, non-labour incomes and consumer choices from which we may be rewritten as:

Then the consumer-worker's second stage utility maximization problem, 3.7,

be non-labour income or savings out of labour income \( t \) \( is positive \),

\( \forall X \in \mathbb{R}^k \) \( \forall t \)

some prices and, "income" can be negative

and (ii) the consumer's choice set is a subset of the non-negative orthant.

Instead of being the entire non-negative orthant.

The model of this section generalizes the work of

utility function, provided that the consumer does in fact have a consistent

market data in order to construct an approximation to the consumer's true

seems to have been the first to propose an algorithm which uses observable

choices can yield information about his preferences. However, for

It is well known that the systematic observation of a consumer's

3. The estimation of utility functions via the revealed preference approach

\[ \forall n \in \mathbb{N} \]

curves, which are generated by the sets \( A_2 \)
Definition: The $i^{th}$ cross-coefficient $d_{ij}$ is defined as $d_{ij} = \frac{x_i - \bar{x}_j}{\sigma_i \sigma_j}$

We now use the market data to define a set of cross-coefficients $\{d_{ij}\}$

Set $\mathcal{X}$ has a nonempty intersection with the consumption possibilities $\{x \in \mathbb{R}^n : \forall i \in \mathcal{J}, x_i \leq \bar{x}_i\}$ for $i = 1, \ldots, I$, the budget set $B$, and $\mathcal{C}$.

$x$ is a closed subset of the set $\mathcal{S}$ defined by (2.2.1) and

$\mathcal{C} = \mathcal{C}_1 \times \mathcal{C}_2 \times \cdots \times \mathcal{C}_N$, where $\mathcal{C}_n$ exhibits local non-satiation and is continuous from above.

$x$ is a real valued function of $n + K$ variables and is

$\mathbf{3.2.2}$ Assumptions on $f$ and $x$:

(known) consumption possibilities set $\mathcal{X}$ satisfies the following conditions:

However, we do need to assume that the (unknown) utility function $f$ and the

in the problem can be constructed from the observable market data

solving a linear programming problem where the coefficients occurring

It turns out that both of these questions can be answered by

utility maximization

utility function $f$, assuming that the observed data is consistent with

the second question is how can we use the observed data

problem maximize $f$ for $x \in \mathcal{X}$ such that $\forall i \in \mathcal{J}$, $x_i \in \mathcal{C}_i$

the maximization problem $f$, i.e., is $x^*$ a solution to the maximization

could the observed data (unknown) $\bar{x}_i$ have been generated as solutions to

The first question we would like to have answered is the following:

- 17 -
\[ T \}
\[ \{ I' \}
\begin{align*}
\text{Definition:} & \quad \text{Maximum } Z(x) \text{ is } T \quad \text{if } x \in \mathbb{R}^n \\
\text{Problem 3.4 and the vectors } \{ A_i \}^T, \{ b_i \}^T \text{ are given market data.} \\
\text{are taken from the solution to the Linear Programming} \\
\text{where the constants} \\
\text{are defined by the functions } f^T y^T & \quad \text{if } i = 1, \ldots, I, \quad x \geq 0, \quad b_i \geq 0, \quad b_a \geq 0, \\
\text{In fact, in the latter case of a zero objective function, we may} \\
\text{data are consistent with utility maximization.} \\
\text{Problem 3.4 is zero when evaluated at an optimal solution, then the observed} \\
\text{on the other hand, if } f^T y^T \text{ the data are revealed to be inconsistent with utility maximization.} \\
\text{by the utility maximization problem 2.1, } f \text{ and } x \text{ satisfy assumptions} \\
\text{then the observed data } \{ A_i \}^T, \{ b_i \}^T \text{ could not have been generated.} \\
\text{positive when evaluated at an optimal solution } \{ x \}^T, \{ b_a \}^T, \{ s_i \}^T, \{ u \}^T \\
\text{Theorem: If the objective function of the Linear Programming problem 3.4 is} \\
\text{by zero.} \\
\text{the objective function of the Linear Programming problem is bounded below.} \\
\text{Note that there is always a feasible solution for 3.4 and that} \\
\text{for } i = 1,2, \ldots, I, \quad x_i \geq 0 \\
\text{For } i \neq x_i \leq 0 \\
\text{subject to} \\
\text{Consider the following Linear Programming problem:} \\
\text{we will have } x \text{ reveal less preferred to } x^T \\
\text{is closely related to the revealed preference concept; i.e., if } d > 0, \\
\text{The concept of a cross-coefficient is due to Arrow (i), and it} \\
\end{align*}
functional form for the utility function, the derived demand functions are other.

However, the problem with this approach is that it does illegally assume a "flexible" approach parameters using econometric techniques. For example, Stone (19) uses this approach.

The unknown parameters of the utility function (in order to estimate the unknown parameters) result in the utility function (and labor supply functions) which contain the resulting system of derived demand (and labor supply) functions, which contain consumer's constrained utility maximization problem, and then use to assume a functional form for the consumer's utility function, solve the constrained utility maximization problem, and then use the indirect utility function approach to estimating a consumer's preferences.

4. The estimation of preferences via the indirect utility function approach

We now turn to a more econometric method to estimating a consumer's utility function. We do not have to make any assumptions about the functional form of the consumer's utility function.

The results of this section can be viewed as giving us a non-parametric method of approximating an approximation to a consumer's utility function, which satisfies the same properties. Since any finite amount of observable data will not be able to contradict these rather strong regularity properties, the true function of size is characterized as just a function in the C^1 and non-increasing functions. It is interesting to note that the approximation of the utility function $f$ is very similar to the proof of theorem 3.1 in (9).

A detailed proof of theorem 3.5 will not be given here since it is very similar to the proof of theorem 3.5. The data is calculable from observable data. The same market data, note that this $f^*$ is calculable from observable data. Thus, the function $f^*$ is consistent with the same market data, note that this $f^*$ is calculable from observable data. For $x^* \in \mathbb{R}^+$, $f^*(x)$ is defined by $x \in \mathbb{R}^+$ and $x^*$ non-increasing in $x^*$, since $f^*$ is non-increasing in $x^*$, we have

$3.8$ Maximize $f^*(x)$ $x \in \mathbb{R}$

Thus the function $f^*$ defined by $x \in \mathbb{R}^+$ can be taken to be an $x^*$ maximizing the solution to the maximization problem:

If the linear programming problem 3.4 has a zero solution, then it
The direct utility function is non-negative, continuous from above, quasi-concave.

The equivalence between the direct and indirect utility functions is given by the Shapley-Bury Theorem, as extended by Haavel (26) and the part of the Shapley-Bury Theorem (21) as extended by Houthak (26). If {X, x}, the indirect utility function may be expressed as the direct utility function. The indirect utility function may be used to calculate the direct utility function. It is a vector.

What is not so well known is the fact that the indirect utility function determined by the function μ.

By solving a constrained maximization problem and the function is completely determined. Given that this budget constraint is \( \sum x_i \geq 0 \). Note that the consumer can attain, given the indirect utility function \( \phi \) gives to the maximum utility.

By "Income", \( \overline{\phi} = \sum x_i \) where each price is divided by a vector of normalized prices, i.e., each price is divided by a vector of normalized vector of consumer decision variables, \( x = \hat{\phi} \) a non-negative vector of consumer decision variables.

The consumer's utility function, \( \phi(x) \) is maximum, \( \overline{\phi} = \sum x_i \) where each price is divided by a vector of normalized variables, \( \overline{\phi} = \sum x_i \).

The maximization is defined as follows:

The indirect utility function is available if we make use of the concept of the indirect utility function, consistent with optimizing behavior on the part of the consumer. A much simpler method of obtaining a system of derived demand parameters is impossible to derive algebraically or are extremely nonlinear in the unknown.
The indifference curves drawn in Figure 4.2 are similar to those of Figure 4.1. These indifference curves correspond to

taking the utilities to be the utilities of the orthogonal utility function x: y.

where \( C_i \), \( \ldots \), \( C_n \), \( L_i \) \( \ldots \), \( L_1 \) and \( H \) are defined as in 2.4. For example, if

\[
(1, \ldots, 1) 
\]

we have a new utility function defined by

The consideration of the utility function

is the first step in the transformation of variables, as well as those whose conditions are not satisfied for problem 2.7. These positive, and these positive conditions are not satisfied.

orthogonal, \((1, \ldots, 1)\) that all pieces are non-negative, and \(h(x)\) that the homogeneous constructure of the direct utility function is defined over the entire non-negative consumer-utility maximization problem given by 2.7 because it assumes

However, the above procedure cannot be applied immediately to the

and then the system of derived demand functions is written by 4.3.

and the system of derived demand functions is written by 4.3.

The above result provides us with an extremely simple method of obtaining

\[
\frac{\partial x}{\partial p} = \frac{1}{\sum_{i=1}^{n} \frac{1}{p_i}}
\]

is given by 4.3.

then Roy (49, 219) has shown that the consumer's system of derived demand functions

differentiable with respect to the components of the normalized price vector, \( v \),

is the inverse indirect utility function in one
do not decrease in the components of \( x \), then the inverse indirect utility function

vice versa.

vice versa.
Vector $y$ will be non-negative.

$$y^T \mathbf{H}^T \mathbf{X} \mathbf{Y} = y^T$$

The variables $C_1, C_2, \ldots, C_L, C_{-1}, \ldots, C_{-L}$ are subject to the constraint $u(x)$.

4.5 Maximize $u(x)$ subject to $u(x)$.

4.4 Maximization problem 4.5 may be written more compactly as:

$$\begin{align*}
\text{Maximize} & \quad u(x) \\
\text{subject to} & \quad u(x) \geq 0 \\
\end{align*}$$

If we drop the time constraint 4.5 (i) for the time being, the

$$\begin{align*}
\text{Maximize} & \quad (x-I)^T \mathbf{H}^{-1} (x-I) \\
\text{subject to} & \quad H-I \geq 0 \\
\end{align*}$$

5.3 Terms of the new utility function $u$ can now be represented in

be extended to the entire non-negative orthant.

Note that the domain of definition of the new utility function may

5.4.1.5.4.2
for purposes of econometric estimation, we may drop any one of the
reduces to the ordinary fixed proportions least squares utility function.
If $q = 0$ for all $i$, then the direct utility function
corresponds to a reduced form (homothetic) Generalized Least Squares utility
where $q = 0$ for $j = 1, 2, \ldots, N$, then the direct utility function which

\[
q + \frac{1}{N(N+1)} \sum_{i=0}^{N} \frac{1}{q} = \frac{1}{q} + \frac{1}{N + N+1} \sum_{i=0}^{N} \frac{1}{q}
\]

Note that the derived second derivatives are homogeneous of degree 4.

The system of consumer demand and labor supply function given by (4.8) below, for

\[
\frac{1}{N(N+1)} \sum_{i=0}^{N} \frac{1}{q} = \frac{1}{q} + \frac{1}{N + N+1} \sum_{i=0}^{N} \frac{1}{q}
\]

5.7 Labour supply with nonhomothetic utility

The utility function which corresponds to the indirect utility function

\[
\text{utility function, } \nu(x)
\]

Consider the following functional form for the inverse indirect
utility function, with the relations 4.5.3 and systems of derived demand equations consistent with 4.6 may be obtained

\[
4.7 \quad \nu(x) = \frac{1}{N(N+1)} \sum_{i=0}^{N} \frac{1}{q} + \frac{1}{N(N+1)} \sum_{i=0}^{N} \frac{1}{q}
\]

Now we are in a position to define the indirect utility function by means of
of equations:

These manipulations lead to the following system equation for \( r = 2, 3, \ldots, N+k \), \( N+k \) on the right hand side of each.

collect all terms involving the unknown \( q_j \)'s on the right hand side of each.

transitional equations; impose the symmetry constraints, \( q_1 = q_{1+N} \) and finally, on the other hand, use this last equation to eliminate \( q_1 \) from the \( N-1 \) terms:

of equation \( 4.8 \) (for \( r = 2, 3, \ldots, N+k \)) \( \cdots \).

equations of 4.8 (for \( r = 2, 3, \ldots, N+k \)) \( q_1 = q_{1+N} \).

which is more amenable to interactive regression techniques: multiply both sides of

by 4.8 may be transformed into a mathematically equivalent system of equations.

It should be noted that the system of derived demand equations given

encounter the usual aggregation problems.

If we wished to apply the model to aggregate time series data, we

consumers into reasonable homogeneous groups.

graphic variables such as level of assets should be used in order to classify.

graphic variables such as age, family composition, education and some non-demo-

that each consumer in the sample had the same mean preferences, the usual demo-

of consumers, we would need variation in relative prices plus the assumption

isolation of the form 4.9. If we are applying the model to a cross section sample

using non-linear least squares on \( N+k-1 \) of the equations 4.9 subject to a normal-

equations are independent. The unknown parameters \( q_j \) could be estimated by

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N+k equations given by 4.8 since the budget constraint will imply that not all
Following the system of equations:

\[
\begin{aligned}
\text{and set the } i^\text{th} \text{ partial derivative equal to } h_i, \text{ a given number, we obtain the } & \frac{d}{dX} A(i, a) \\
\text{when calculating the first order partial derivatives of } y \text{ evaluated at } & h_i = \frac{d}{dX} \left( \frac{d}{dX} A(i, a) \right) + \left( \frac{d}{dX} A(i, a) \right)_x \\
\text{let } h(i, a) = (k_1, \ldots, k_{n+1}, i, a) & \\
\text{at the point } & h(i, a) \\
\text{utility function which has the same first second order partial derivatives as } & h(i, a) \\
\text{there exists a nonhomogeneous generalized lorentzian } & h(i, a) \\
\text{which has second order partial derivatives } & h(i, a) \\
\text{utility function which has first second order partial derivatives } & h(i, a) \\
\text{arbitrary inverse differentiable indeterminate } & h(i, a) \\
\text{lemma: let } h(i, a) & \\
\text{be an arbitrary twice continuously differentiable inverse indeterminate map.} &
\end{aligned}
\]

By the provided reasonability of local approximation to an arbitrary preference result indicates that the nonhomogeneous generalized lorentzian form allows have provided a good approximation to the underlying preferences. The following good approximation to an arbitrary inverse differentiable utility function, then we will

\[ h(i, a) = (X^k, A(i, a)) \]

Thus if we can find a functional form which provides an arbitrary inverse differentiable utility function that preferences can equivalently be represented by the direct utility function as we have mentioned before, it is an implication of duality theory

\[ 0 \leq \pi \leq m \]

\[ \text{exponentially where } \pi_A = \frac{1}{\pi_A} \text{ or are conditional on the values of the right hand side variables,} \]

\[ \text{using linear regression techniques, it we assume that the distribution of the unknown } \pi \text{ in the system of equations 4.10 can be estimated} \]

\[
\begin{aligned}
\text{for } i = 1, \ldots, n+1, \ldots, m & \\
\frac{\pi_A}{\pi_A} & + \frac{\pi_A}{T_A U - T_A A} m q^2 + \frac{\pi_A}{X} u^{n+1} + \frac{\pi_A}{X^{n+1}} u^{n+1} +
\end{aligned}
\]
because if we normalize the system by dividing each \( d_i^T (A) \) by the common factor

\[ 4.10 \quad p_i^T q + p_i^T q + \frac{\alpha}{2} p_i^T q = 0 \]

where equation 4.16 follows, if the inverse indirect utility function \( h \) is given

\[ 4.15 \quad p_i^T q = (A) \quad \beta (A) = (A) \quad p_i^T q = (A) \]

systems of unnormalized demand functions by

\( p_i^T \)'s In this latter case we may proceed as follows, defining the consumer's may not have enough degrees of freedom in order to estimate a complete set of have a large number of goods in our model and relatively few observations, we function which satisfies the appropriate regularity conditions. However, if we function which satisfies the appropriate regularity conditions. Hence, if we

Thus we now have a satisfaction for the functional form given by

4.1.2. Are then determined by using equations 4.12.

4.1.4 Because, the \( p_i^T \)'s may be determined by solving the equations 4.14. The \( q_i^T \) are determined, the \( p_i^T \) may be determined by solving the equations 4.14. Once the off diagonal \( p_i^T \) are to solve for the unknown \( p_i^T \) for \( i \neq n+1 \). We assume that all \( \frac{\partial^2 h}{\partial x_i \partial x_j} \) in which case equations 4.12 can be used

\[ 4.14 \quad \sum_{i=1}^{n} \sum_{j=1}^{n} q_i^T q_j = (A) \quad (A) \quad q_i^T q_j = (A) \]

\[ 4.13 \quad \sum_{i=1}^{n} \sum_{j=1}^{n} q_i^T q_j = (A) \quad (A) \quad q_i^T q_j = (A) \]

systems of equations at

if we calculate the second order partial derivatives of \( h \) evaluated

\[ 4.12 \quad \sum_{i=1}^{n} \sum_{j=1}^{n} q_i^T q_j = (A) \quad (A) \quad q_i^T q_j = (A) \]
The year. If the worker is aware of the fact that his wage rate is a function of

take home wage rate a declining function of the number of hours he works during
that the effect of the progressive tax structure is to make the consumer-worker's
and nonlabour earnings (which can be taken to be fixed in the short run) we see
earnings of their industries, as earnings can be decomposed into labour earnings
namely, most Western countries impose a progressive income tax structure on the

we now turn our attention to a compilation of some practical importance:

\[ \text{Monopsonistic Consumer Demand Theory} \]

To relax this somewhat restrictive assumption,

decision variables \( C_i \), \( N_i \) and \( I_i \).

In the following section, we will

\[ P_i, N_i \text{ and the wage rates } \{ w_i \} \]

This is the above analysis assumes that the consumer-worker regards the prices

behaviour.

artificial system of derived demand functions, consistent with utility maximization

demand equations defined by 4.8 can provide a good local approximation to an
consistent with the consumer's budget constraint. Finally, the system of derived
also the consumption demands and labour supplies defined by 4.8 are
income \( V \). Also the consumption demands and labour supplies defined by 4.8 are

functions given by 4.8. For example, the demand functions given by 4.8 are homo-

several advantages to fitting the system of consumer demand and labour supply
because of aggregation problems for example, we can still assert that there are

4.6 or if we apply the model to situations where it may not be appropriate

even if consumers do not optimize according to the model given by

green grounds, to estimating only the dominant substitution effects.

in the price \( \beta \) then we may set \( \beta = 0 \). Thus we can restrict ourselves on a

If we suspect that the unmeasured demand for good \( i \) is not responsible to changes

\[ Z_i = 0 \text{ for example, } \]

\[ \sum_{i=1}^{N} \alpha_i x_i \]

Now
one of his decision variables (the number of hours of labour services he offers during the period under consideration), then the utility maximization problem given by 2.7 can no longer model the consumer-worker's behavior. Thus we must transform the "competitive" utility maximization model 2.7 (i.e., prices and wages are taken as fixed parameters) into a "monopsonistic" utility maximization model proceeding to the general case, let us consider first the diagrammatical form of the following very simple example 6.2.

5.1
Maximize $f(C, L)$

w.r.t. $C \geq 0, L \geq 0, w \geq 0$

\begin{align*}
(1) & \quad pC - wL = 0 \\
(2) & \quad L \leq H \\
(3) & \quad w = w(L)
\end{align*}

where $f$ = the consumer-worker's utility function,

$C$ = consumption in real terms during the period,

$p$ = rental price of one unit of the consumption good,

$L$ = number of hours of labour services supplied, where $W(L)$ = the take home wage function with $w > 0$, $L > 0$, and $w'(L) > 0$,

$V$ = nonlabour income spent during the period,

$H$ = number of hours in the period.

Note that in addition to $C$ and $L$, $w$ is also a decision variable.

If the wage function constraint 5.1 is substituted into 5.1, we obtain a nonlinear budget constraint which is graphed below in Figure 5.1. The curves $l_0, l_1, l_2$ represent indifference curves corresponding to the utility function $f$. The point $(c^*, l^*)$ represents the consumer-worker's equilibrium consumption labour supply point and his equilibrium take home wage will be $w(l^*)$. 

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First present the analysis which is applicable to the case of a differentiable utility function. The above procedure can be generalized to a number of directions. We are given an appropriate body of data, the unknown utility function \( f \), and we may be used in order to obtain an approximation to the problem given by 5.2 of the same structure as 2.7 and thus the

\[
\text{Maximize } f(C, L, T) \\
\text{subject to } L \geq 0, \quad T \geq 0
\]

Following Interpreted Version:

has been constructed, the constrained maximization problem 5.1 can be replaced by the linearized budget line. Since the appropriate linearized budget line is also known, we can construct the constrained from the market data. Hence, if the linearized budget line can be constructed from the market data, the point \((C^*, L^*, T^*)\) may be interpreted as the intersection of the true budget line around the point \((C^*, L^*, T^*)\) which is simply the labor supply point if we replace the nonmonetary (true) budget line. Figure 5.1 still be the consumer's equilibrium consumption.
\[ x = \text{the consumer's observed decision vector}, \]
\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]
\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]

5.3

\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]

5.4

\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]

5.5

\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]

5.6

\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]

5.7

\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]

5.8

\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]

5.9

\[ \text{subject to (f)} \quad \max \text{subject to (f)} \]
\[ x \in \mathbb{R}^n \]
bracket. The geometry of the new problem is illustrated below in Figure 5.2.

Let us briefly re-examine the example given by 5.1 when the take home

with the non-differentiable case.

certain conditions, we can modify the analysis of section 5 of this paper to deal
points, thus rendering the budget function \( v(x) \) non-differentiable. However, under
income taxation, the marginal tax rises change discontinuously at certain fixed
is not differentiable. For example, in most countries where there is progressive

Importantly, in many practical problems, the budget function \( v(x) \)

differentiable budget function \( v(x) \).

The above procedure which converts a "competitive" consumer

defined in 4.6 by the normalized prices defined by * in 5.4

may be used in our present context; simply replace the prices \( x \) which were
functional form techniques which were used to model the problem given by 4.6 and the same

Thus the problem 5.4 is of the same structure as 4.6 and the same

\[ U' = \frac{\partial v(x)}{\partial x} \]
The budget constraint is given by \( x \in M \) with \( x = (x_1, \ldots, x_n) \). We will impose some regularity conditions on the utility function \( u \) and the observation \( x \) could have been generated as a solution to the following constraints:

\[
\max_{\{x \in \mathbb{R}^m : e(x) \geq 0\}} u(x)
\]

Let us assume that we have the consumer-worker's budget constraint given by \( B(x) \) and we wish to know whether vectors \( x \in \{x \in \mathbb{R}^m : e(x) \geq 0\} \) are such that \( z \in B(x) \). Let us suppose we are given a finite number of observed decision vectors \( x \) are not implementable, as we shall show below.

The difficulties are not insurmountable, as we shall show below. However, the difficulties are not determined by the slope of the budget line. In the differentiable case, the slope of the indifference curve through \( (x_1, x_2) \) at the point \( (x_1, x_2) \) is the right-hand derivative of the budget line through \( (x_1, x_2) \), whereas in the non-differentiable case, the slope of the indifference curve through \( (x_1, x_2) \) is the difference between the slopes given by the right and left-hand derivatives.

If the consumer chooses the point \( (x_1, x_2) \) then assuming maximizing behavior on the part of the consumer, all we can deduce is that the slope of the consumer's indifference curve at this point is the slope of the indifference curve. One part of the budget constraint is given by \( z \in B(x) \) which makes the estimation of preferences from market data much more difficult than it is in the case of a differentiable budget constraint.

If we do not know the shape of the indifference curve, but we observe that the data at this point. It is true that knowledge of the budget set \( B(x) \) which distinguishes Figure 5.2 from Figure 5.1 and which makes the estimation of preferences from market data much more difficult than it is in the case of a differentiable budget constraint.

At this point, we see that the point \( (x_1, x_2) \) lies on the indifference curve which is tangent to the consumer's feasible budget set \( B(x) \). But the budget set has a Khan curve, 0.1 and 1 are indifference curves of the consumer's utility function. The curves 1.0, 1.1, and 1 are indifference curves of the consumer's utility function.
Now consider the following linear programming problem:

\[
\begin{align*}
\text{Minimize: } & \sum_{j \in J} c_j x_j \\
\text{Subject to: } & \sum_{j \in J} a_{ij} x_j \leq b_i, \quad i = 1, \ldots, I; \quad x_j \geq 0, \quad j = 1, \ldots, J
\end{align*}
\]

5.6

Definition: \( d_{ij} = \sum_{j \in J} a_{ij} x_j \)

By 3.7, since we must redefine the cross coefficients as follows:

Recall the definition of the cross coefficient \( d_{ij} \) which was given

\[
\text{vector of prices} \quad \alpha \text{ and } \beta \text{ is a fixed scalar, non-tradable income} \]

\[
\text{written as } Y^T A \hspace{1cm} (Y \geq 0, \hspace{1cm} \alpha, \hspace{1cm} \beta)
\]

\[
\text{For } i = 1, 2, \ldots, I, \text{ every tangent hyperplane to the set } B_i \text{ at the point } x_i \text{ can be}
\]

assumption on the sets \( B_i \) and on the observed decision vectors \( x_i \):

Finite set of (extreme) hyperplanes; i.e., we make the following additional

set of tangent hyperplanes can be generated by taking convex combinations of a

set \( B_i \) at the point \( x_i \). We will make the further simplifying assumption that this

set \( B_i \) is a bounded, convex set for \( i = 1, 2, \ldots, I \) (vi).

\[
(\forall) \text{ } X_i \text{ is a nonempty, closed, bounded, convex set, and for } i = 1, 2, \ldots, I
\]

\[
(\forall) \text{ } \ell \text{ is a quasi-concave function, and}
\]

\[
(\forall) \text{ } \ell \text{ is a quasi-concave function, and}
\]

\[
(\forall) \text{ } \ell \text{ exhibits local non-saturation, and}
\]

\[
(\forall) \text{ } \ell \text{ is continuous, from above, as assumptions on } f \text{ and the sets } B_i.
\]

5.6
scope have been made in recent years. The only approach thus far found feasible of present taxes upon factor supplies. Several empirical studies of rather limited study, but can provide no answers about the actual direction or magnitude of effects.

Economic analysis outlines possible reactions and avenues for empirical

technique? For example, consider the following quotations:

of ascertaining consumer preferences which is often suggested as the only feasible preference. Our approach should be compared with the personal interview technique

the observed choices of the consumer-worker in order to infer something about his section are both based on revealed preference theory. That is, we use

resulting system of derived demand and labor supply functions (presumed in this

Note that the two methods of estimating consumer preferences (and the

tax rates on labor supply).

this estimated ε, in order to simulate the effects of changes in wages, prices or

an approximation to the consumer's true utility function J, and we could use

A again, the function \( \varepsilon(x) \) may be used as

be given here since the proof closely resembles that of 3.5.

A detailed proof of the restricted version of theorem 3.5 will not

Problem 5.9 and the vectors \( (x^k) \) are defined in 5.9.

where the constants and \( x_0 \) are taken from a solution to the linear programming

\[ \text{Definition: } \varepsilon(x) = \sum_{i=1}^{k} \left( \sum_{j=1}^{l} \left( A_j^k \right) \right) \]

3.4 is replaced by the linear programming problem 5.9, and the functions \( \varepsilon(x) \) are defined by 3.2 is replaced by 5.6 and 5.7, the linear programming problem

We can now restate theorem 3.5 almost word for word, except that 3.1 is

\[ \text{for } i = 1, \ldots, k \]

\[ \text{for } i = 1, \ldots, k \]
household utility maximization problem 2.4 now becomes:

\[
\text{Subject to }
\]

households are qualified to offer different types of labor services. The old case where the household has more than one member and various members of

6.1 Extension to Households

interest in techniques that are somewhat greater than the data requirements for the preference techniques are somewhat greater than the data requirements needed to implement our revealed

situations. However, the data requirements needed to implement market responses to market situations in order to infer their responses to future market

Hypothesized question: It seems more satisfactory to use the consumer's actual

what variable does the consumer is holding constant when he gives his reply to a to ascertain consumer responses to tax changes since it is difficult to determine

In our view, the interest in techniques is not the appropriate technique

promise of producing concise results in the Canadian case (4:25).

complex forces governing working behavior. Alternative techniques hold little

only if this way that taxation can be placed in perspective as merely one of the

out a survey which made use of the technique of personal interview; for it is

in Canada. To establish the point conclusively it would be necessary to carry

No study has been undertaken of how income taxes affect work effort

choice of occupation, and related decisions" (19; 176)

In closing, it is interesting to ascertain the significance of taxes for work-performance.
members of the household during various intervals of time within the basic period

\[ \text{hours in it.} \]

occupation which is open to him during the period of time which has

\[ \text{the household budget constraint, the constraints} \]

\[ \text{hours in it.} \]

which has \( H \) hours in it,

occupation which is open to him during the period of time which has

\[ \text{the household budget constraint, the constraints} \]

\[ \text{hours in it.} \]

which has \( H \) hours in it,

occupation which is open to him during the period of time which has

\[ \text{the household budget constraint, the constraints} \]

\[ \text{hours in it.} \]

which has \( H \) hours in it,
The time constraints (6.4) in order to express \( \eta_j \) in terms of \( \eta_j \) and the first
last component of each of the vectors \( \eta_j \), and
where \( \eta_j \) \( \in \) \( X \) (i) where \( \eta_j \) \( \in \) \( X \) (i) and \( \eta_j \) \( \in \) \( X \) (i) for \( j = 1, 2, \ldots, m \).

We may now use the time constraints (6.3) in order to eliminate

\[
\begin{align*}
\min & \quad \eta_j \\
\text{s.t.} & \quad \eta_j = 0 \\
& \quad \eta_j \geq 0 \\
& \quad \eta_j \geq 0 \\
& \quad \eta_j \geq 0 \\
& \quad \eta_j \geq 0 \\
& \quad \eta_j \geq 0 \\
& \quad \eta_j \geq 0
\end{align*}
\]

subject to

maximize utility function \( u \) given by (5.1). However, we can use our techniques in order to estimate

outlined in section 3 of this paper in order to estimate the utility function

of labor service during the periods of time which have \( H \) hours in them.

Time constraints of the members of the household who are unable to offer any type
of time which has \( H \) hours in it and the constraints given by (5.1) represent the

- 37 -
The utility maximization problem given by 6.7 is much the same as 2.7.

\[ \text{Maximize} \quad f(\mathbf{c}_1, \ldots, \mathbf{c}_J, \mathbf{d}_0, \mathbf{d}_0, \ldots) \]

subject to

\[ \sum_{i=1}^{J} \mathbf{d}_i \leq \mathbf{d}_0, \quad \mathbf{d}_0 \geq 0 \]

This again, the function \( f \) has absorbed the details of the household's internal allocation of time and the household's external, utility maximization.

Thus again, the function \( f \) has absorbed the details of the household's internal allocation of time and the household's external, utility maximization.

function: \(
\text{utility function } u \text{ defined by } 6.2 \text{ in order to define the following derivative utility}
\)

\[ \text{utility function } u \text{ defined by } 6.2 \text{ in order to define the following derivative utility} \]

\[ \text{utility function } u \text{ defined by } 6.2 \text{ in order to define the following derivative utility} \]

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\[ \text{utility function } u \text{ defined by } 6.2 \text{ in order to define the following derivative utility} \]

\[ \text{utility function } u \text{ defined by } 6.2 \text{ in order to define the following derivative utility} \]
A paper will doubtless be useful in modeling some of these intertemporal allocations.

The framework used in this paper, however, might not be as good as in other contexts. Here, there are still many problems. In this context, work decisions could change with respect to changes in prices, wages, and household outcomes. In this paper, we could be used to predict how the household's consumption and outflows change.

In conclusion, we note that although the model of household behavior may be sufficient in some cases, it may not be sufficient in others. In the short run, this may cause the household to enter the labor force. The opportunity cost of this time may differ substantially in the long run and this may cause the female to work in a given period. Then if the female becomes unemployed,

6.7 and let 6.7 be scalars representing the number of hours the female works. Let 6.7 be in a model. The female labor force participation decision, let 6.7 be very

More than the model of household behavior, given by 6.7 could be very

to the problem of estimating the 6.7 with minor modifications.

The preference estimation techniques outlined in sections 5 and 6 can be applied

6.7 has J time constraints while 7.7 has only a single time constraint. However,

the main difference being that the feasibility regions are somewhat different.
Section 2, "Duality Theory and Functional Forms for Systems of Demand Equations."

Utility function and the related topic of duality theory, see Dewett (17).

For an extensive discussion and historical references on the indirect
utility function, see Christensen (9), or Green (4) or Perelman (45; 63-76).

For an example of this approach see Stone (4) or Christensen (9). See Green (42) or Perelman (45; 63-76).

and other demographic variables.

holdings and the standard age, sex, location, family composition, education

at each job, consumption services expended during the period, asset

of labour service he supplies during a period alone with the hours spent

of the data we need are earnings by sex indutrial at the various types

and leisure (17).

consistent with consumer theory, see Christensen (9), Lucas and Haggio (3).

attempts to derive aggregate labour supply functions for the United States

However, the econometric procedures were not insurmountable. For some recent

See, for example, Model (7); 129-131; or Perelman (45; 4-7).

Dewett (14).

A very crude model of disaggregate labour supply may be found in

see Dewett (14).

neoclassical production function approach for determining labour demand.

are of the fixed coefficient or Leontief (39) type. For an example of the

The manpower requirements approach assumes that all production functions

and Ahmed (2).

1 For examples of this approach, see the studies of Meltz and Penz (36).

some helpful comments.

For any approximations or errors expressed in this report, Larry Epstein has made

of the Department of Manpower and Immigration but they are not responsible

British Columbia. This research has been financed by the Research Branch.

"The author is presently an Associate Professor at the University of
Some examples of basic commodities are sleeping (requires inputs of time and the services of a television set) and eating (requires time and the services of a bed). Watching television (requires time and the service of a television) could also be counted here.

15 Time spent in household investment activities such as attending "income" to order to consumption services.

14 Note that Hodkins (as well as many other writers) used the term service.

assumed that the consumer could supply many different types of labor. consumer who could supply only one type of labor service whereas mathematic functions, Deon's restricted his mathematical analysis to the case of a

13 Both Jevons (3:th ed and Marris (5:th ed) assumed separable utility

needed is a synthesis of the two approaches.

Supply - Leisure demand decision, see the essays in chapter 6). What is

some examples of the sociological approach in the context of the labor

focus their attention on the determinants of preference formation. For

in prices assuming their preferences are constant whereas sociologists

Thus economists focus their attention on how consumers react to changes

presented here to the intertemporal case among the Issues of demand (7).

However, it is not too difficult to extend the one period analysis

of uncertainty on work or occupational choice.

10 Moreover, (4:th gives a particularly good discussion of the effects

Inconclus. (continued)
Labour supply and labour force participation is based on the hypothesis that

contract. Actually, although a great deal of empirical work in the area of

20

see Stone (54) for an application of this technique in somewhat different

case.

be reduced by one, whereas this reduction is not possible in the rationing

with equality (and thus the dimensionality of the consumer's choice set may

quality, whereas in our present context, the time constraint always holds.

concerns, either one of these constraints can be satisfied with a strict l

as well as a rationed goods constraint, depending on the consumer's prefer-

for an illustration of this case, where a consumer faces the usual budget constraint.

Thus the present model differs from the rationing model (see Stigler 53)

occupational choice.

period of time and thus the model is unable to deal with problems of

2.1: i.e., the price of time is uniquely determined in each "signature causes

this more generalized model has the same weaknesses as the model represented by

consumer-worker may be different in these different time intervals. However,

at his "priming time" job and thus the opportunity cost of time for the

weekends or nights, the consumer may not be able to earn as much as he can

components give the number of hours in each interval of time. Thus during

consumer's time during each time interval! Finally if is a vector whose

the transpose of the vector of wage rates which determines the value of the

vector of labour supplied offered at different intervals of time and w represents

is allowed to be a vector of time inputs into the production of Z. Let is a

represents the transpose of the corresponding vector of rental prices, p.

By 2.1, Becker allows each C to be a vector of consumption goods and p

18 Actually, Becker's model is somewhat more general than the model given

our of his labour income during the period.

If V is negative, then the consumer saves the absolute value of V

Footnotes (continued)
activity.

Household work activity will be a close substitute to the \( c \) variable which

leisure activities for him. Thus each \( u \) variable which corresponds to a

to undertake household work but he cannot hire labour services to undertake

that the consumer can hire labour services (which appear among the \( c \) variables)

such as cleaning, washing dishes, cooking, changing diapers, and so on. Note

activities such as eating, sleeping, reading as well as household work activities

32 Examples of household activities which require time are leisure type

service which the consumer has purchased during the period.

22 \( c \) could refer to the number of units of a particular kind of labour

not be labour force participating.

consumer-worker will decide to offer zero hours of \( l \) in which case he will

the labour force participation decision, i.e., it can be the case that a

Becker's theory of the allocation of time does give us a theory of

21


consistent with utility maximization. The estimated labour supply function

consistent with utility maximization. The estimated labour supply function in the context of a complete system of

estimates the labour supply function in the context of a complete system of

where \( (37) \) is the Lucas and Rapine (32) function, \( (36) \) is the

and Beeman and Price (37), Pesen (32), Hoare (32), and

the Lucas and Rapine (32) function, (37) is the Lucas and Rapine (32)

This is not the case for example, the work of Douglas (38),

the consumer-worker has consistent preferences defined over combinations of

(continued)
However, what is new is the demonstration of 2.7 from the more general

to consumer responses to changes in the exogenous variables.

exogenous variables (prices, wages and non-labour income) and obtain simultaneous

solve the constrained maximization problem 2.7 for different values of the

income allocation information.

information on the households' allocation of time, but without the corresponding

household time. However, there are a few studies (1), (2) which give some

In fact, it is difficult to obtain any information on the allocation of

but we must be consistent in our elimination.

function U. It does not matter which L we eliminate from problem 2.4.

some L different from L I then we would obtain a different derived utility

If we choose to use the time constraint 2.4 (11) in order to eliminate

type of labour service.

equals zero, even though our consumer-worker is qualified to offer the L

If no employment opportunities exist in the L occupation for him, then we

from the point of view of the particular consumer-worker under consideration.

Note however that the wage rates refer to occupational wage rates

example.

this intertemporal approach and treatment (3) and (4) for empirical

(2) and Hicks (227, 229) for an exposition of the theoretical foundations of

the consumer had a consistent set of intertemporal preferences. See Pishner

if we took a "life cycle" point of view; that is, if we assumed that

consumer's saving decision could be made an endogenous decision variable

allocation (variable) from the point of view of the consumer-worker.

Footnotes (continued)
This result follows from a straightforward application of the maximum theorem.

From above function at \( x_0 \), we have used part (11) of the above maximum theorem.

Let a compact set and let \( \theta \) be an upper semicontinuous correspondence from \( S \) into \( X \). Let \( f(x,y) \) be a continuous from above real valued function on \( S \times X \), where \( X \) is a sequence of points in such that \( y_n \to y \) and \( x_n \to x \) (c.f. 12.19).

The lower semicontinuous at \( x_0 \) \( \Rightarrow \) If \( \lim \ x_n = x \), \( \forall n \), then \( \lim \ f(x_n, y) = f(x, y) \) is a continuous from below function at \( x_0 \).

A correspondence from \( S \times X \) into \( X \) is continuous from below if and only if \( \lim \ f(x_n, y) = f(x, y) \) is continuous from below real valued function on \( S \times X \).

Proved the theorem as two separate results. (1) Let \( f(x, y) \) be a continuous function defined on \( S \times X \). However, theorem (6.199-1.16) stated and proven by Denney (11, 11989-8090), 1719. However, theorem referred to is known as the maximum theorem and was initially

For a further explanation of the concept of an upper semicontinuous correspondence, see [12, 17].

For an explanation of the concept of a correspondence, see [4].

See Denney (12, 6) for an exposition of the concept of a correspondence.
prices prevalent during period t to be positive, for i = 1, ..., I.

If \( Y_{0t}^{1} \), then we need every component of \( P \) (the vector of goods
we do need one additional assumption in order to accomplish the above program.
in (7b) but it is straightforward to do this, given assumptions 3.2. However,
we also need to move the counterparts to Lemmas 2.2, 2.4, 2.5, and 2.6.

Programming.

See Barnett (17) for an exposition of the relevant theory of integer
work, which may be found in Pethran (1957-58).

This observation contradicts the received theory of overtime
premium rates. Thus, observation contrasts the received theory of overtime
to explain why a rational worker may not choose to work overtime, even at
the "knucklebone" of the "effective" indifference sets \( V(n) \) may be used.

Let \( X(n) \).

Note that if \( X \) intersect the set \( A \), \( X \) with the set \( X \), we obtain the set
for each \( i \).

\[ \begin{align*}
X(1) & = \{ x : x \in X, x_{1} \leq 1 \} \\
X(2) & = \{ x : x \in X, x_{2} \leq 2 \} \\
& \vdots \\
X(I) & = \{ x : x \in X, x_{I} \leq I \}
\end{align*} \]

Mathematically, \( X(n) \) is defined as the convex hull of the set \( X \).

From his straightforward wage rate,

In section 5, we allow the worker's overtime wage rate to be different

Miller (41).

Some of these problems have been explored by Moses (39) and Moses and

37 scalar such that \( 0 \leq \frac{1}{2} \), implies \( \chi + (1 - \chi) y ; y \in S, \)

L(n) \( x : x \in \mathbb{R}^{n} \) (are convex, a set \( S \) is convex if \( x \), \( y \) \in S, \( x + y ; y \in S \).

Then we would expect to find "third" indifference sets.

Consumers do not bother to discriminate between alternatives very closely,

Footnotes (continued)
4. Note that the $\alpha$ and $\gamma$ vectors defined by (4.6) are different from the $\alpha$ and $\gamma$ vectors in the Proter's internal expenditure system (4.5).

5. The functional form used in (4.14) corresponds to an approximation to the true $f$. It is easy to show that a concave function is also quasiconcave.

$F(x)$ is concave over a convex set $I$ if

$$F(x) = (1-\gamma) + (\gamma x) + x \gamma (x - 1) \text{ for } I \subset [0,1],$$

and $\gamma > 0.$ The term $b(\gamma)$ is due to Houthakker (30).

For an excellent exposition of these functional form problems, see Corden (24).

If $f(x)$ is approximated to the first order, a utility function is approximated to the second order, then the derived demand function will be approximated to an arbitrary twice differentiable utility function. If $f(x)$ is a twice differentiable functional form, there is one which is capable of providing a second-order approximation to the true $f$. It is easy to show that a concave function is also quasiconcave.
Aspects of this case have been considered by Frisch (22; 14).

...
This assumption is needed in order to ensure that solutions $x^*$ to the
larger number of hours spent on the job, whose total costs of travel time to work will be attributable to a
moment (since the fixed costs of travel time to work will be attributable to a non-progressive income tax for the
household's wage rate will be $w^*.$) The consumer-worker offers on the job, the greater
more hours of labour service the consumer-worker offers on the job, the greater be part of the time spent on the work activity. Thus in this latter case, the
work location decision, since time spent traveling to work can be considered to
when overtime wage rates differ from straight time rates, and (v) the consumer's
rates depend upon the amount of education undertaken, (iv) the work decision
associated with the household's investment in education decision where future wage
goods depend on the amount of time the consumer allocates to search, (iii) problems
with (iv); (ii) certain search and transactions costs models where prices of
depend on the consumer's location decision (see for example Alonso (2)) or
are (ii) the consumer's urban location decision where the rental price of
households in education decision where future wage
are (ii) some examples of problems which can be treated in the "monopolistic framework
surface at the equilibrium point.

Budget surface may be replaced by the (linear) tangent hyperplane to the budget
consumer. Since the indifference surface encloses a convex set, the nonlinear
budget surface is tangent to the highest feasible indifference surface of the
which implies that the level sets of $u$ are convex. In equilibrium, the nonlinear
function of the two problems rests on the quasi-concavity of $u$,

and partial derivatives.

\[
\frac{\partial u}{\partial x_i}(x) = \begin{cases} 
0 & \text{if } x_i = 0, \\
\text{defined as the appropriate price and wage functions.} 
\end{cases}
\]

where $w$ is a monotonic function which can be determined if we know the relevant
cartridge's', the consumer's budget constraint can be expressed in the form $v(x)$, decision
variables, $x$ is the case when there is a progressive tax on labour
in particular, if prices or wages are a function of any of the consumer's

Footnotes (continued)
another can only be amortized over several time periods.

regional mobility of labor, where the costs of moving from one location to
investment in education decision and (iii) problems associated with the inter-
temporal context are (i) the household's savings decision, (ii) the household's
75
some of these problems which can be successfully modeled only in an inter-

74 Recall 2.6 in section 2 of this paper.

for \( j = 1, 2, \ldots, n \) and \( k = 1, 2, \ldots, k \).

individual's, but at different time intervals. Note also that \( H, D, H, H \), and \( H, H, H \)
individuals, that at different time intervals. Thus, the index \( j \) on \( H \) in 6.1 may refer to the same
during evenings or weekends. This way, the index \( j \) on \( H \) in 6.1 may refer to the same
person's job opportunities may be very different
to allow for the fact that a person's job opportunities may be very different
hours in it into a group of non-overlapping time intervals of shorter duration
since we may follow Becker (549) in decomposing the period of time when
the household does not have to concern \( j \) potential members of the labor force
sort of labor service during the period which has \( H \) hours in it. Note that
73 We assume that the \( j \) th member of the household is capable of offering some

hypotheticals can be approximated sufficiently closely by a finite set of hypotheses.

assumption is not too restrictive since any infinite set of extreme supporting
problem (10) can be used. However, from a practical point of view, the finiteness
the linear programming problem 5.9 into a variable coefficients programming
72 This finiteness assumption can be relaxed put only at the cost of computing

of the budget sets (but it did require differentiability).

71 Note that the earlier analysis in this section did not require convexity

with linear budget constraints.

70 Note that this assumption was not needed in section 3 when we were deriving

maximization problem 5.5 occurs on the boundary of the budget set, \( B \).

(continued)
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