DECISION BASED ECONOMIC THEORY

by

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SUMMARY

Decision based economic theory stresses the central position of the objective function in the behavior of economic agents. Insufficient knowledge of objective functions hampers the development of economic theory. In this article, a methodology for deriving objective functions from conscious decisions has been developed. Three categories of decisions are concerned: positive, negative, and mutually exclusive decisions. Assuming minimal inconsistency, the objective function can be derived by means of linear or nonlinear programming and using a revealed preference approach. The method has been applied to derive the linear objective function of EC dairy policy. However, applications of this methodology for consumers and producers are similar. A number of issues related to the formulation and interpretation of the objective function are discussed.

1. INTRODUCTION

In decisionmaking environments like a consumer household, a firm, or a government, one typically starts from a utility or objective function. While the objective function of a firm seems to be very well known in literature (e.g., many books start right from the beginning with a profit maximizing behavior), the utility function of the household and the objective function of a government-type organization seems less well known. Many economists even choose not to make a complete specification of a utility function or an objective function. They assume some regularities, such as concavity or quasi concavity, and only specify derived functions like demand functions for products and government behavioral functions.

Here we will follow a different approach. This approach starts with the general formulation of an objective function.[1] The further specification of the objective function will be derived from a number of decisions made by a household, a firm, or a government and will "reveal" information about objectives. All these decisions are placed in a general framework and from these total number of decisions an objective function may be derived. Therefore, we will call it a decision based economic theory (DEBET).

The approach rests on a number of elements:

- A sufficient number of decisions made by the decisionmaker which completely determine the objective function.
- An assumed consistent behavior of the decisionmaker (e.g., no switch to a new or different objective function).
- A criterion function for weighing apparent inconsistencies in the behavior of the decisionmaker and/or the calculated effects of the decision by the researcher.

In section three we state the theory, which is further elaborated in sections four and five. A particular application to determine the objective function with respect to EC dairy policy is given in section six. Here we derive the objective function of the Council of Ministers and the Commission of the European Community. In section seven, we introduce a number of related aspects while in section eight, the merits and demerits of the approach are discussed.

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[1] Throughout this paper, the name objective function will be used for all names like: utility function, preference function, target function, etc.

2. BACKGROUND OF PRESENT ECONOMIC THEORY

Before presenting our methodology, we will give a short and limited overview of some main areas of economic theory. This sketchy overview functions as a background for the decision based economic theory.

One can observe a clear convergence in the methodology of consumer and producer theory (Deaton and Muellbauer, 1980; Fuss & McFadden, 1978; Diewert, 1982; Varian, 1984). The economic theory of the household can be formulated in a very simple way by:

$$\max U = U(X) \quad (1)$$

$$\text{s.t.} \quad p \cdot X = Y \quad (2)$$

where (1) represents the utility function of the household and (2) the budget restriction. Even more simple is the revealed preference theory where only a preference relationship has been assumed, while the utility function has been dropped from the analysis. This theory totally concentrates on the budget restriction (Samuelson, 1983; Houthakker, 1950; Varian, 1984). Clearly there is a tendency to circumvent the specification of a utility function because relationships like the Hicks or Marshall demand functions can be derived easily from the present theoretical framework without specification of the direct utility function (1). Especially duality theory has contributed to such an approach, where only a small number of weak assumptions are made about the utility function or the preference structure. The theory has become so elegant that it is nearly impossible to refute the basic assumptions (see Deaton & Muellbauer, 1980, Chapter 3).

The same type of development, but to a lesser extent, can be observed in production theory. Here the basic approach is:

$$\max W = W(Z,r) \quad (3)$$

$$\text{s.t.} \quad F(Z) = 0 \quad (4)$$

where (3) represents the profit function with inputs and outputs--or netputs--Z and prices r and (4) the production function or transformation function. Here one observes a tendency, especially in theoretical developments, to circumvent the specification of the production function. Assuming concavity of the production function, a direct formulation of the profit function (or cost-function) is preferred above an explicit specification of the technology. Equivalent to consumer theory, a production function or transformation function can be circumvented by assuming a closed connected production possibility set (Varian, 1984, section 1.16). And one can easily derive the demand functions for inputs and the supply function of output from (3) and (4).

Also, here there seems to arise an approach where, using a minimal number of assumptions, the basic theory is very elegant and nearly unrefutable. Even negative test results (e.g., Burgess, 1975; Appelbaum, 1978) or a large number of observations that are not in accordance with the basic theory (e.g., see Lopez, 1984) gives no way to change assumptions.

With respect to government behavior, economic theory started in the following way:

$$\text{Find } q, \text{ such that } t = \bar{t} \quad \text{or } \max G(t,q) \tag{5}$$

$$\text{s.t.} \quad H(t,q) = 0 \tag{6}$$

where (5) is the target or objective function of the government and (6) the economic model of the relationship between the target variables (t) and instrument variables (q). (The left-hand side of (5) is according to Tinbergen (1952), the right-hand side of (5) has been used by Theil (1964), among others.) Later on one can observe a tendency to drop the explicit formulated objective function from this framework and to investigate more the structure of government behavior (Frey, 1978; Krueger, 1974; Peltzman, 1976). One can also infer that the objective function will be dropped from the analysis, only assuming some regularity conditions. The analysis will concentrate completely on (6), together with derived relationships. This would be in line with developments in consumer theory.

However, we argue for a more central position of the objective function in economic theory and also a more risky methodology in economic research. Several alternative specifications of the objective function could make tests of economic models against data more worthwhile. Empirical evidence on these functions can give more strength to several areas of economic theory.

Of course, there are approaches that also work along these lines such as:

- The formulation of utility functions on the basis of risk behavior (Anderson et al., 1977; Hildreth & Knowledge, 1986).
- Developing the individual welfare functions (van Praag, 1968; van Praag & Kapteyn, 1973; Kapteyn, 1977; van Herwaarden & Kapteyn, 1981) of the household.
- Broadening the number of variables, incorporated in the utility function of the consumer (Deaton & Muellbauer, 1980, Chapter 4 and 10-14) or the objective function of the firm

(Officer and Halter, 1968; Pope, 1980; Robison & Barry, 1986).

We try to give more strength to these and other approaches which can broaden the empirical content of economic theory.

3. GENERAL FORMULATION OF THE THEORY

The theory starts from the decisions made by a decisionmaking unit. This can be an individual, a consumer (e.g., an individual considered with respect to a restricted set of decisions such as buying and/or using goods and services), a family/household, a firm or the management of the firm, or a government or local authority, etc. We assume that the decision-making unit has a preference relation for the consequences of possible decisions. Say that a number of objective variables are of interest for the decisionmaker. Then from standard revealed preference theory (Samuelson, 1983; Varian, 1982), we can state that the particular decisionmaker prefers the perceived consequences of the chosen state of objective variables to any other state that belongs to his possibilities. Although this might seem an attractive starting point to determine the preference structure of the particular decisionmaker, we can state that this starting point assumes:

- complete information about all possible decisions
- rational behavior of the decisionmaker.

Both assumptions have been challenged in economic theory (Simon, 1955, 1978; Stiglitz, 1985). Moreover, why should we consider all choice possibilities of the decisionmaker if we can derive his/her preferences from a limited number of conscious decisions? Therefore, we limit the analysis to the following three categories of decisions:

1. The decision to change something (e.g., one of the variables that could be decided on by the particular decisionmaking unit and which influences the perceived consequences of one or more of the objective variables).
2. The decision not to change any of the objective variables (indirectly), although a particular option has been considered.
3. The decision to prefer a particular choice above another choice that has been considered in situations of mutual exclusivity.

Category 1 we will call positive decisions, category 2 negative decisions, and category 3 mutual exclusivity decisions. The reason for these names will become clear later on. Scheme 1 gives a global description of some decisions for a household, a firm, and a government. This scheme is only to indicate which type of decisions are meant.

Scheme 1. Illustration of a number of decisions for the household, firm and government

Type of decision Decision-maker	1 Positive decision	2 Negative decision	3 Mutual exclusivity decision
Household	To buy a car/ house (+loan)	Not to buy a car/house	To prefer a car/ house to different ones (+ loans)
	To accept a job	Rejecting a possible job	Choosing between alternative jobs
	To buy a basket of goods in a particular shop	1)	Choosing between different options of buying a basket of goods
	To spend the day in a recreational park	Staying at home	Choosing between alternative parks
Firm	New investment (+financing)	No investment	Making a choice between alternative investment plans (+ financing)
	Changing the production plan	No change of the production	Choosing between different production plan
	Introducing a new way of marketing	No change of marketing	Making a choice between alternative marketing strategies
	Changing the financial structure of	Keeping the same financial structure	Choosing between alternative ways of financing
Government	Constructing a particular road	Cancelling a plan for a particular road	Choosing between alternative options for a road
	Passing an act	Going on with existing legislation	Making a choice between alternative options for option
	Choosing a particular policy	Going in with present policy	Making a choice between alternative options

1) For some goods, like food, a negative decision does not seem probable.

4. A MORE FORMAL APPROACH

To formalize our approach, we start with a number of very common definitions.

Definition A: A particular state j of the objective variables will be represented by $X^j = X^j_1,\ldots,X^j_I$, where I is the total number of objective variables.

Definition B: The initial state of the objective variables (e.g. the situation without a decision that leads to a change of the objective variables) will be represented by $\bar{X}^j = \bar{X}^j_1,\ldots,\bar{X}^j_I$.

Definition C: The preference relations are stated as follows:

$X^j \succ X^k$ iff[2] $v(X^j) > v(X^k)$
(strict preference of j above k)

$X^j \sim X^k$ iff $v(X^j) = v(X^k)$
(j and h are equally preferred)

$X^j \succsim X^k$ iff $v(X^j) \geq v(X^k)$
(k is not preferred above j)

Here v is the objective function that relates a number to every state of the objective variables: $v_j = v(X^j)$.
Stated in this form, this implies that the objective function is a function of the following form:

$$v: R^I \rightarrow R$$

However, we will represent the objective function in the parameterized form:

$$v: R^I \times R^N \rightarrow R \qquad (7)$$

where N is the total number of parameters of the function v.
For given values of the objective variables, v is a function of the N parameters of the objective function.
Now a decisionmaking unit makes a number of decisions during a particular period, say J of category 1, K of category 2, and M of category 3. Then we can state the following (in)equalities:

$$v(X^j) - v(\bar{X}^j) > 0 \qquad (j=1,\ldots,J) \qquad (8a)$$

$$v(X^k) - v(\bar{X}^k) \leq 0 \qquad (k=1,\ldots,K) \qquad (8b)$$

$$v(X^m) - v({}^mX^j) \leq 0 \qquad (m=1,\ldots,M) \qquad (8c)$$

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[2] means if and only if.

(Here ${}^{m}X^{j}$ is the particular alternative that has been chosen in a mutual exclusivity situation.)

This formulation implies:

- A decisionmaking unit strictly prefers the new situation when a decision is made to change something.
- In case of mutual exclusivity, or without a change, equal preference is not excluded.

The (in)equalities (8a) to (8c), together with the general form of the objective function, is the available set of information. From this available set of information we will try to derive the objective function of the decisionmaker. However, first we will make one assumption and we will introduce a new function.

The inequality (8a) can be rewritten as follows:

$$v(X^{j}) - v(X^{j}) - \delta_{j} \geq 0 \qquad (j=1,\ldots,J) \qquad (8a')$$

where δ_j is an arbitrary, possibly small, positive constant representing a decision threshold and measured in the same units as the functional value of the objective function. For the time being, we will neglect the δ's, but we will return to them in section 7.

According to the definition given in (7), the objective function v depends on the state of the objective variables (X^j) and the parameters of the objective function, represented by the N-dimensional vector w. We define the difference function g between the "more" and the "less" preferred alternative, X^j and X^k, respectively:

$$g(w;X^{j},X^{k}) = v(X^{j}) - v(X^{k}) \qquad (9)$$

$$\text{Here } g: R^{N} \times R^{I} \times R^{I} \rightarrow R \qquad (10)$$

However, for given values of X^j and X^k, this function g only depends on the N-dimensional vector of parameters w.

Now our system of (in)equalities (8a)-(8c), given our assumption made about (8a') and the difference function in (9) and (10) can be written as follows:

$$g(w;X^{j},\bar{X}^{j}) \geq 0 \qquad (j=1,\ldots,J) \qquad (11a)$$

$$g(w;\bar{X}^{k},X^{k}) \geq 0 \qquad (k=1,\ldots,K) \qquad (11b)$$

$$g(w;{}^{m}X^{j},X^{m}) \geq 0 \qquad (m=1,\ldots,M) \qquad (11c)$$

It is an interesting question, of course, if the total number of J + K + M restrictions on the function g will completely determine the parameter vector w of the objective function. Without further specification of the objective function, no general statements can be made.

However, it may be expected that for a sufficient number of decisions and a specific type of objective function, the restrictions (11a)-(11c) define an empty set: no parameter set of the objective function can fulfill these restrictions. This can be due to:

- inconsistent behavior of the decisionmaking unit
- differences between the calculated consequences of the decisions and the consequences perceived by the decisionmaker.

To allow for "bounded rationality," we may introduce some "constants" that represent inconsistencies and differences. If we add such constants to each equation, then we obtain an unlimited number of solutions. This unlimited number of solutions, however, is restricted by the requirement that the sum of all constants is at a minimum value.

Therefore, the system (11) can be rewritten as:

$$\min_{z} \sum_{j=1}^{J} a_j + \sum_{k=1}^{K} b_k + \sum_{m=1}^{M} c_m \qquad (12)$$

subject to:

$$g(w;X^j,\bar{X}^j) + a_j \geq 0 \quad (j=1,\ldots,J) \qquad (13a)$$

$$g(w;\bar{X}^k,X^k) + b_k \geq 0 \quad (k=1,\ldots,K) \qquad (13b)$$

$$g(w;{}^mX^j,X^m) + c_m \geq 0 \quad (m=1,\ldots,M) \qquad (13c)$$

$$a_j,\ b_m,\ c_k \geq 0$$

where the vector z = (w a b c), has a length of N + J + K + M. Here, a, b, and c are the vectors with constants.

Clearly this is a nonlinear optimization problem. However, without further specification of the function v and thereby the function g, it is difficult to say under which conditions the parameters w can be derived by solving this nonlinear optimization problem. We will state the general conditions that a particular solution vector, say $\hat{z}$ with $\hat{w}$ as the solution for w, will be a global minimum. First, however, we make the following remarks:

1. All functions g in (13), when they are considered as functions of the parameter vector w, can be different. This is due to the X-vectors. Properties of the functions g depend on the specific values of these X-vectors.
2. Depending on the type of objective function v, it can be necessary to restrict (or scale) the parameters w of the objective function v. Such restrictions can be introduced quite easily in a nonlinear optimization framework. We will call them <u>additional restrictions</u>.

The conditions for finding an optimal solution (e.g. a global minimum) of (12), subject to (13) and the additional restrictions, can be derived from:

1. The Kuhn-Tucker sufficiency theorem. Here it is required that function g is differentiable and concave with respect to w. Moreover, the Kuhn-Tucker minimum conditions should be satisfied (Chiang, 1984, p. 729 and pp. 738-740).
2. The Arrow-Enthoven theorem. Here it is required that the function g is differentiable and quasi concave with respect to w. Furthermore, the Kuhn-Tucker minimum conditions should be fulfilled. Quasi-concavity is a sufficient condition because the objective function is convex with respect to z and, thus, w (Chiang, 1984, p. 744-746).

Because the second approach is less restrictive, it is sufficient when function g is differentiable and quasi concave with respect to the parameters w. This, together with the Kuhn-Tucker minimum conditions, guarantees a global minimum for a derived solution.

Checking the quasi concavity of the functions g with respect to w in (13) requires J + K + M checks. Uniform quasi concavity of the objective function v with respect to w is not a sufficient condition because g is the difference between two functions.

5. <u>SIMPLIFYING ASSUMPTIONS AND SOME FURTHER ELABORATION</u>

In section 4 we introduced the most general form of the theory. It is a serious drawback that finding a global minimum for (12) is uncertain. Moreover, finding an optimal solution by means of nonlinear programming might be a tedious job. The origin of the problem is related to the general form of the objective function v. In this section, we will successively introduce a number of restrictions on the objective function which make the function easier to determine. Restricting the flexibility of the objective function also limits the need for information. Moreover, we will formulate a general approach which approximates any "well behaved" objective function v. These restrictions or approximations give way to a solution procedure using linear programming.

In the last part of this section, we will discuss restrictions on the parameter vector w. Such restrictions are also required to prevent a trivial solution. Besides that, a performance measure will be introduced.

5.1 Simplifying Assumptions About The Objective Function

The general objective function, introduced in section 4 can be restricted to a function that is linear in its parameters:[3]

$$v = \sum_{n=1}^{N} w_n \cdot v_n(X^j) \tag{14}$$

Here v_n is a known function of X^j:

$$v_n: R^I \rightarrow R \qquad (n = 1, \ldots, N)$$

Therefore, the functions v_n are independent of the parameters w. Many flexible form functions can be used. Under this assumption, the difference function $g(w;X^j,X^k)$ defined in (9) also simplifies:

$$g(w;X^j,X^k) = \sum_{n=1}^{N} w_n \left[v_n(X^j) - v_n(X^k)\right] \tag{15}$$

where the expression between the square brackets is only a function of the known consequences of the decision.

Defining $h_n(X^j;X^k) = v_n(X^j) - v_n(X^k)$, the minimization problem now reads:

$$\min_z \sum_{j=1}^{J} a_j + \sum_{k=1}^{K} b_k + \sum_{m=1}^{M} c_m \tag{16}$$

$$\text{subject to: } \sum_{n=1}^{N} w_n h_n(X^j;\bar{X}^j) + a_j \geq 0 \qquad (j=1,\ldots,J) \tag{17}$$

[3] The formulation of this function can even be slightly more general, assuming that the unknown parameters $(w_1,\ldots,w_N)$ can be derived from a set of parameters $(u_1,\ldots,u_N)$ after a transformation, where (14) is not necessarily linear in the u's.

$$\sum_{n=1}^{N} w_n\, h_n(\bar{X}^k;X^k) + b_k \geq 0 \qquad (k=1,\ldots,K)$$

$$\sum_{n=1}^{N} w_n\, h_n({}^mX^j;X^m) + c_m \geq 0 \qquad (m=1,\ldots,M)$$

$$a_j,\ b_k,\ c_m \geq 0$$

while some additional restrictions on the parameter vector w should be added. Here z is again the row vector with w and the vectors of constants a, b, and c as elements. Additional restrictions on w will be necessary, otherwise the trivial solution w = 0 leads to the minimum value of (16). We will return to this point in subsection 5.3.

This is clearly a <u>linear programming problem</u> where the optimal solution gives the parameters $(w_1,\ldots,w_N)$ of the objective function, when a sufficient number of various decisions are incorporated. Notice that here the number of parameters N is, in general, larger than the number of objective variables: I.

Detecting an objective function by means of linear programming is, of course, a considerable simplification. Moreover, there are no restrictions on the form of the objective function, apart from the linearity of the parameters.

A specific example of the above mentioned objective function (14) is the well known quadratic objective function (Theil, 1964):

$$v = c + d'y + (y-\bar{y})'A(y-\bar{y}) \qquad (18)$$

where: c is a constant[4]

$\bar{y}$ is an I-dimensional vector of objective variables

d is an I-dimensional vector of (linear) weights

y is an I-dimensional vector of target values for the

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[4] The constant c cannot be derived from the whole procedure; any c will give the same difference function. We will return to this point in section 8.

objective variables

A is an (IxI)-matrix with "weights" for the quadratic elements of the objective function

Here we assume that the target values are known; otherwise, (18) belongs to the class of objective functions defined in section 4.

Now we will show the effect of further restrictions on the objective function, which implies no change of the solution procedure but requires less information.

Consider an objective function like:

$$v = \sum_{i=1}^{I} v_i(X_i) \tag{19}$$

$$\text{where } v_i: R^{d(i)} \times R \rightarrow R \qquad (i = 1, \ldots, I) \tag{20}$$

and d(i) = the number of parameters for each objective variable. This is a function with preferential independence of the particular objective variables (Keeney & Raiffa, 1976, p. 111).

A specific form of (19) that has been elaborated quite intensively by Shrinivasan & Shocker (1973a; 1973b) is:

$$v = \sum_{i=1}^{I} \alpha_i \,(X_i - \mu_i)^2 \tag{21}$$

This is a weighted function with m as the target vector or ideal point. Here, the difference function h is:

$$h = \sum_{i=1}^{I} \alpha_i \,[(X_i - \mu_i)^2 - (\bar{X}_i - \mu_i)^2] \tag{22}$$

where X_i and $\bar{X}_i$ are observations on the objective variables in two different situations. Equation (22) can be rewritten as:

$$h = \sum_{i=1}^{I} \alpha_i \,(X_i^2 - \bar{X}_i^2) - 2 \sum_{i=1}^{I} \beta_i \,(X_i - \bar{X}_i) \tag{23}$$

where: $\beta_i = \alpha_i \, \mu_i$

This function is linear in its parameters α and β, and the objective function can be derived from a sufficient number of revealed preferences.[5]

A linear homogeneous CES function in its general form:

$$u = a_0 \left[\sum_{i=1}^{I} w_i X_i^p \right]^{1/p} \tag{24}$$

can be transformed to:

$$v = \left[\frac{u}{a_0} \right]^p = \sum_{i=1}^{I} w_i X_i^p \tag{25}$$

For a prespecified value of the substitution elasticity ($\sigma = 1 - \frac{1}{p}$), this function can be linearized by converting to a logarithmic form.

$$v = a_0 \prod_{i=1}^{I} (X_i - \delta_i)^{w_i} \quad \text{(the utility function which belongs to the linear expenditure system)} \tag{26}$$

and

$$v = a_0 \prod_{i=1}^{I} X_i^{w_i} \quad \text{(log-linear function)} \tag{27}$$

can be easily linearized and be brought directly in the optimization framework defined in (16) and (17). For equation (26), however, the elements of the vector g should be known.

The most simple objective function is linear:

$$v = \sum_{i=1}^{I} w_i X_i \tag{28}$$

Here, the difference function of two decisions $h(X^j, X^k)$ is equal to $x^{jk} = X^j - X^k$, where x^{jk} is the vector of differences between the alternatives j and k. So, even the level of the objective variable is unimportant.

These objective functions illustrate a number of possible formulations which can all be detected in a linear programming framework.

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[5] Srinivasan & Shocker (1973a, p. 345) also handle the problem that $\alpha_i = 0$ and $\beta_i \neq 0$. In that situation, the function in (21) "degenerates" to a linear objective function.

5.2 A more general approach to derive an objective function that is linear in its parameters

Although many functions can be formulated that are linear in the parameters, a procedure that would approximate every "well-behaved" function into a linear framework would be useful. Here we start from a Taylor approximation to a twice differentiable objective function, at $w = w_o$:

$$v(w;X) = v(w_o;X) + Dv(w_o;X)' \ (w - w_o) + \tfrac{1}{2}(w - w_o)' \ D^2v(w_o;X)(w - w_o) + R \quad (29)$$

where: $Dv(w_o;X)$ is the first derivative of v with respect to w at w_o,
$D^2v(w_o;X)$ is the second derivative of v with respect to w at w_o,
R is the remainder.

The difference function h for two sets of the objective variables (X^j and X^k) is linear in its parameters:

$$h(w;X^j,X^k) = v(w_o;X^j) - v(w_o;X^k) + [Dv(w_o;X^j) - Dv(w_o;X^k)]'(w - w_o) + \tfrac{1}{2}(w - w_o)'[D^2v(w_o;X^j) - D^2v(w_o;X^k)](w - w_o) \quad (30)$$

This second order approximation is equal to Eqn. (18). A first order approximation is similar to the approach starting with a linear objective function.

5.3 Restrictions on the parameter vector and a performance measure

Restrictions on the parameter vector w are necessary to circumvent the trivial solution where w = 0 and the minimum value of zero will be obtained for the target function of the LP (see eqns (16) and (17)). Without any further information about the particular objective function v, it is difficult to give general statements for solving this problem. Moreover, restrictions on the parameters can be used for several reasons, e.g.,

(a) to fulfil theoretical restrictions of the particular objective function.
(b) to measure the objective function in a handy unit.
(c) to give easy access to performance measures of alternative specifications of the objective function.

Besides reason (a), which should be applied always, we will mention two different strategies.

The first strategy sets a particular element of the parameter vector at 1; say $w_n = 1$ $(n = 1,\ldots,N)$.

This implies also that the objective function v and also the target function of the LP will be measured in the units of this particular objective variable.[6] This may improve the interpretation of the results. However, one can also influence the result, e.g., by picking a variable for which otherwise w_n would be equal to zero.[7] Therefore one should make a careful choice of the scaling parameter.

The second strategy is more difficult to understand; this strategy has been developed by Shrinivasan and Shocker (1973a). They start from two different measures:

- the "poorness of fit" (B); which is the value of the target function in the final solution of the LP-problem.
- The "goodness of fit" (G); which is the sum of the slack values of the LP solution.

Using our framework, defined in (16) and (17), together with additional restrictions, the difference between both measures is:

$$G-B = \sum_{j=1}^{J} \sum_{n=1}^{N} w_n h_n(X^j;\bar{X}^j) + \sum_{k=1}^{K} \sum_{n=1}^{N} w_n h_n(\bar{X}^k;X^k) + \sum_{m=1}^{M} \sum_{n=1}^{N} w_n h_n({}^{m}X^j;X^m) \qquad (31)$$

By setting G-B equal to a particular constant, say 1, the trivial solution will be evaded. Moreover, Shrinivasan and Shocker (1973a) prove that, with the vector of parameters w only restricted to non negative values, this restriction only influences the scaling of the objective function v.

They also define a performance measure of the final solution: B/G. This measure is bounded by zero and one; a low value indicates a good performance. The same measure can be used under the first strategy.

6. AN APPLICATION

In this section we will give a short description of an application, to detect the objective function for European Community dairy policy. This is a typical environment where several objective variables are relevant and where a variety of heterogenous policy instruments are used.

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[6] This will not hold for a transformed objective function; here one should incorporate the effect of transformation.

[7] Without further restriction on the parameter vector (except $w \geq 0$), rescaling is always possible unless $w_n = 0$.

The main decisionmaking bodies are the Council of Ministers and the Commission of the European Communities.

National interest, pressure from interest groups and advise form advisory organizations play an important role in the process. Individual ministers of the Council quite often have opposite interests. Decision-making takes place by qualified majority or unanimity and sometimes only decisions about packages of policy decisions can be reached.

Because several "players" or "individuals" and "organizations" play a role in the decisionmaking process, the resulting objective function can be subject to Arrow's General (Im)possibility Theorem (Arrow, 1966).* However, restricting the domain condition and/or the "independency of irrelevant alternatives," a workable social welfare function can be established (Johansen, 1969). We even go further to postulate a "cardinal" objective function for EC dairy policy.

We start from a linear objective function and the following objective variables:*

1. administrative feasibility
2. equilibrium of international trade
3. price stability
4. producers' income
5. consumers' income
6. EC budget costs
7. EC income

Variables 1, 2, and 3 have been measured in their own units, while the other variables are measured in billion ECUs of 1983.

To determine the objective function for the EC dairy sector, one starts with a number of instruments that the EC is using at this moment, e.g.,

- intervention prices for butter and skimmed milk powder;

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* This theorem states that: there is no "social welfare function" that relates preferences from each "player" to "social preferences" which satisfies: (1) the general domain condition, (2) the Pareto principle, (3) the condition of nondictatorship, and (4) the "independence of irrelevant alternatives."

* This is the "important" subset of objective variables used in a policy decision model for the dairy policy of the European Community (Oskam, 1987). Other variables have been dropped because their weight may be assumed to be limited and the computed effects are less reliable.

intervention prices can be considered as the minimum price level for the producer.

- co-responsibility levy; a levy for producers to afford product and market development and subsidy schemes.
- domestic and external sales of subsidized dairy products: the so-called surplus disposal measures.
- refunds for exported dairy products: a type of export subsidies.

Furthermore, some "significant" policy decisions have been made in recent years, such as:

1. The introduction of the so-called super levy in 1984. The is a specific quota system for milk producers. By doing this, preference was given to a super levy rather than to a price reduction of 12 percent (according to the European Commission: Commission, 1983, p. 16.).
2. Temporary increase in the milk quota in 1984 (1 percent) plus an increase in the co-responsibility levy.
3. Suspension of quota in 1987/88 and 1988/89 by a total of 4 percent and 5.5 percent, respectively, accompanied by income compensation. This implies that quotas were reduced, but producers received compensatory payments.

All decisions have been made in the period 1980-1987.

A short description of each policy decision is given in Appendix A. In total, 28 policy decisions were incorporated. The effects were calculated by means of the EC dairy model and by a number of additional calculations. For a complete overview of the calculated effects, see Table 1.

Table 1: Calculated policy effects of some arrangements for the EC dairy sector

No.	Description	Period	Effects on objective variables[1]							E[3]
			1	2	3	4	5	6[2]	7	
1	Super levy	1984	-1.73	0.34	-0.70	-1.24	0.35	1.86	1.02	Y
2	Super levy	1984-88	-6.94	0.68	-4.74	-4.28	0.80	13.23	8.55	Y
3	Price reduction 12%	1984		1.01	-0.85	-3.36	2.55	1.79	0.66	N
4	" " 12%	1984-88		7.08	-4.68	-15.24	11.35	13.42	9.52	N
5	Lower quotas and coresp. levy	1984	-0.04	0.19	-0.27	0.15	-0.01	-0.01	0.12	N
6	Buy-out programme	1987-92	-0.07	1.57	-2.28	-0.41	-0.28	3.12	2.34	Y
7	Suspension quota 4%	1987	-0.20	1.65	-0.67	0.01	-0.02	0.80	0.79	Y
8	" " +1.5%	1988	-0.06	0.18	-0.29	-0.02	-0.15	0.31	0.36	Y
9	Price increase 1.5%	1985		-0.09	0.16	1.15	-0.70	0.57	-0.05	Y
10	Price reduction 2%	1986		0.33	-0.13	-1.52	1.22	0.59	0.12	Y
11	Price increase 1%	1986		-0.20	0.09	0.71	-0.60	0.42	0.07	N
12	Price reduction 2%	1987		0.38	-0.19	-1.41	1.21	0.62	0.11	Y
13	Coresp.levy +1%	1985-87				-1.88	-0.08	1.81	0.02	N
14	Coresp.levy -1%	1985-87				1.88	0.08	-1.81	-0.02	N
15	Refunds +10%	1985		-1.01			-0.32	-0.17	-0.50	Y
16	Refunds +15%	1986		-0.85			-0.06	-0.45	-0.51	Y
17	Xmas butter	1979/80		0.12			-0.16	-0.031	0.129	Y
18	Xmas butter	1980/81		0.06			0.102	-0.044	0.058	N
19	Xmas butter	1982/83		0.07			0.136	-0.071	0.065	Y
20	Xmas butter	1983/84		0.07			0.13	-0.076	0.054	N
21	Xmas butter + butter USSR	1984/85		-0.56			0.252	-0.045	0.14	Y
22	Xmas butter	1985/86					0.243	-0.173	0.07	N
23	Xmas butter	1986/87					0.233	-0.166	0.067	N
24	Special sales butter	1980-87		-1.18			1.24	-0.54	0.81	Y
25	Additional special sales	1983-84		0.22			0.244	-0.09	0.154	N
26	" "	1985-86		0.18			0.238	-0.088	0.15	Y
27	Sales to USSR	1986-87		-1.40				0.10	0.10	Y
28	Price reduction butter	1980-87					7.07	-5.99	1.05	N

1) The objective variables 4, 5, 6 and 7 are measured in 10^9 ECUs of 1983.
2) A positive effect on the budget variable (no. 6) implies that budget costs are lower.
3) E = execution: Y = yes; N = no.

Now the following optimization problem has been formulated:

$$\min \sum_{j=1}^{J} a_j + \sum_{k=1}^{K} b_k \qquad (32)$$

$$\text{subject to:} \quad \sum_{i=1}^{I} w_i \, x_{ji} + a_j \geq 0 \qquad (j=1,\ldots,J) \qquad (33)$$

$$\sum_{i=1}^{I} w_i \, x_{ki} - b_j \leq 0 \qquad (k=1,\ldots,K)$$

$$w_i \geq 0$$
$$a_j, \; b_k \geq 0$$
$$w_6 = 1$$

where: x_{ji} and x_{ki} are the calculated effects for the particular objective variables

The first line of the restrictions in (33) refers to the positive decisions (E = Y in Table 1) and the second line to the negative and mutual exclusivity decisions (E = N in Table 1).

6.1. Solving the LP problem

The optimum of the objective function (32), with the restrictions (33) and using data from Table 1, can be found in the left-hand column of Table 2. The weight of the objective variable budget costs (no. 6) has been fixed at one. One of the things this choice implies is that the objective function is formulated in billion equivalent budget ECUs of 1983. The minimum value of the objective function indicates a total "policy inconsistency" of 1.46 billion ECU for the 28 measures examined. This amount seems very small and, moreover, 56 percent of it can be attributed to the increases in refunds in 1985 and 1986 (measures 15 and 16).

The weighting factors for the objective variables "producers' income" and "consumers' income" can be elucidated in the light of other research (Oskam, 1983). The objective variables "price stability" (3), "equilibrium of international trade" (2), and "administrative feasibility" (1) are more complicated. The latter two variables have an implicit weighting equal to zero, but price stability has a very high weight.

The high weight for price stability seems to be far from credible in view of the surpluses prevailing in the dairy sector during the research period. However, this variable may represent a certain importance that is not covered by the seven objective variables included. The variable "price stability" is strongly correlated with the size of the milk production and milk processing. It is possible that the political importance of an extensive milk processing sector is reflected in this variable. Therefore, a second optimization was carried out, adding an upper bound for the weight of "price stability": 0.2. The results are included in the right-hand column of Table 2. These indicate that the administrative feasibility plays a part in the restricted solution. However, concomitantly the weight factor for consumers' income declines.

Table 2. Optimum solution of the LP problem for the weightings of the objective variables

Objective variable	Weighting (no restriction)	Weighting (restriction on the weighting of the price stability)
1. Administrative feasibility	0	0.35
3. Equilibrium of international trade	0	0
7. Price stability	1.13	0.2
8. Producers' income	0.94	0.96
9. Consumers' income	0.55	0.18
10. EC budget costs	1	1
11. EC income	0	0
Optimum value objective function	1.46	2.34

6.2 Results of the optimization

After the weights have been determined, the policy choices that agreed with the resulting objective function can be ascertained. For this purpose, the outcome of being under (= short fall or "slack") and exceeding (= surplus) the inequality restriction per variable is given in Table 3.

Table 3: Position of policy arrangements over the period 1980-1987 for the derived objective function

Arrangement		Period	Execution Y = yes N = no	LP solution without restriction		LP solution with restriction	
				slack	surplus	slack	surplus
1	Super levy	1984	Y	0.09	0	0	0
2	Super levy	1984-88	Y	4.28	0	5.94	0
3	12% price reduction	1984	N	0.94	0	1.12	0
4	12% price reduction	1984-88	N	0	0	0	0
5	Lower quotas and co-resp. levy	1984	N	0.18	0	0	0.06
6	Buy-out programme	1987-92	Y	0	0	2.20	0
7	Suspens.quota 4%	1987	Y	0.04	0	0.60	0
8	Suspens.quota +1.5%	1988	Y	0	0.12	0.18	0
9	Price increase 1.5%	1985	Y	0.31	0	0.43	0
10	Price reduction 2%	1986	Y	0	0.32	0	0.67
11	Price increase 1%	1987	N	0	0.02	0	0.17
12	Price reduction 2%	1987	Y	0	0.01	0	0.29
13	Co-resp. levy +1%	1985-87	N	0	0	0	0
14	Co-resp. levy -1%	1985-87	N	0	0	0	0
15	Refunds +10%	1985	Y	0	0.34	0	0.23
16	Refunds +15%	1986	Y	0	0.48	0	0.46
17	Xmas butter	1979/80	Y	0	0.12	0	0.06
18	Xmas butter	1980/81	N	0	0.01	0.03	0
19	Xmas butter	1982/83	Y	0.00	0	0	0.05
20	Xmas butter	1983/84	N	0.01	0	0.05	0
21	Xmas butter + butter to USSR	1984/85	Y	0.09	0	0.00	0
22	Xmas butter	1985/86	N	0.04	0	0.13	0
23	Xmas butter	1986/87	N	0.04	0	0.12	0
24	Special sales butter	1980-87	Y	0.14	0	0	0.31
25	Add.special sales	1983-84	N	0	0.04	0.05	0
26	Add.special sales	1985-86	Y	0.04	0	0	0.04
27	Sales to USSR	1986-87	Y	0.10	0	0.10	0
28	Price reduction butter	1980-87	N	1.79	0	4.59	0
	Total			8.09	1.46	15.54	2.34
	Performance measure	B/G		0.18		0.16	

slack implies that for a particular objective function, the policy choice has been taken correctly and with a margin. A surplus means that the added variable (see the a or b in (33)) is activated. Then the arrangement does not agree with the objective function. The performance measure, defined in subsection 5.3, divides the total surplus measure by total slack value. This measure is slightly smaller for the restricted solution.

The results of this analysis clearly demonstrate that it is possible to determine an objective function by means of a number of decisions. Because of limited availability of other research results, with respect to preferences in EC dairy policy, we can only compare these results with some information from other research.

Analyzing the price proposals of the European Commission and the price decisions of the Council of Ministers of Agriculture, the mutual weighting of the objective variables "budget" and "producers' income" is determined in Oskam (1983) (see Table 4). It is striking that a greater weight is given to the producers' income than to the EC budget. This may be because the budget limits achieved during the period 1968-1982 were not very firm. The weight given to one unit budget may be increased strongly with higher budget costs.

Table 4: Weighting of objective variables in two studies

Objective variable	Oskam (1983) Commission	Oskam (1983) Council of Ministers	Burton (1985)
Producers' income	1.25	1.41	1.89
Consumers' income	--	--	1.51
EC-budget	1	1	1

At the same time, in this research it was found that both the European Commission and the Council of Ministers attach great importance to the EC contributing to the equilibrium of international trade in dairy products. This could not be revealed over the period 1980-1987.

The results obtained by Burton (1985) do not agree well with Table 2, although the period from which his empirical results were determined is not known. The weight of the producers' income is much higher than in Table 2 and also for Oskam (1983): see Table 4. Second, Burton considered one unit of consumers' income to be more important than one unit budget. However, this does not imply that the results obtained in Table 2 are unreliable.

7. A NUMBER OF RELATED ASPECTS

Now we have introduced the methodology of decision based economic theory and after the application to a particular example, we will give attention to a number of related aspects.

7.1 Relevant Decisions

Within the categories of decisions formulated in section 3, one can restrict the number of decisions somewhat further. Here three different criteria are mentioned.

1. Relevant decisions for determining the objective function. This can be illustrated with an example. When a firm invests in a production plan, then it makes a lot of decisions to buy related inputs afterwards (e.g., variable inputs). Although alternatives may be considered as relevant for detecting the objective function, the decision to buy variable inputs is rather straightforward and will seldom give any information about the objective function. Therefore, one should concentrate on decisions that give information about the objective function.
2. Relevant decisions for the variable of interest for a particular research (area). Mostly empirical research will concentrate on particular variables of the objective function. This also restricts the decisions that are interesting.
3. Including decisions for which good information is available, either with respect to the information used by the decision-maker or information that may be considered as relevant for the particular decision. In this way, one circumvents that large "error terms" bias the resulting objective function.

Because gathering information is quite often a very expensive element in research, and certainly in this type of research, a well balanced choice of decisions may be important.

7.2 <u>Types of Decisions</u>

In 7.1 we concentrated on the relevance of decisions from the researcher's point of view. However, one may also distinguish decisions from the viewpoint of the decisionmaker. Here we will distinguish:

- routine decisions
- unusual decisions
- other decisions

Routine decisions are made several times, such as :

- buying a basket of goods by a household
- buying variable inputs, using advertising campaigns, by a firm
- making annual decisions about tariffs, taxes, prices, etc., by a government.

The important aspect of routine decisions is that the particular decisionmaker has a lot of experience with the outcome of the decisions, and it might be expected that, after some experience, (e.g., a learning period) decisions are made with a low level of inconsistency. On the other hand, decisions can be made so routinely that results might be different from the optimal level: satisficing behavior (Cyert & March, 1963). This would imply that in the longer run, different types of routine decisions might show decreasing optimality.

Unusual decisions are, for example,

- buying a house by a family
- choosing a particular type of education
- building a new factory
- passing a complete new act.

Such decisions are mostly considered seriously, but the perceived consequences may be rather uncertain. Moreover, the experience with the previous decision might induce the decisionmaker to make quite a different choice the next time (see also subsection 7.5 on learning).

In between are the groups of decisions, made on a "not too regular" basis, which can be very important for deriving the objective function.

One might, of course, give different weights to inconsistencies of each type of decision. Besides such an ad hoc procedure, one might also interview decisionmakers about their idea of consistency for each type of decision.

7.3 Comparing Different Objective Functions

Using the same set of observations on the decisions, one might use different objective functions. An important element, of course, is the level of inconsistency following from the particular objective function. However, just like in regression analysis, one can always decrease the inconsistency by adding more parameters to the objective function. Therefore, the choice between different objective functions will be more a matter of subjective evaluation of the performance of each function.

7.4 Decision Threshold

In section 4, we introduced some decision threshold δ for positive decisions. The idea behind the decision threshold is that decisionmakers only change if they can achieve a clear improvement. However, if we would introduce such a decision threshold that is, for example, related to the importance of the decision, we would end up with a larger measure for inconsistency (the value of B/G, defined in subsection 5.3 increases). However, one could also add the same e to the negative decisions and compare the performance measure relative to the decision threshold. When the increase of the performance measure B/G is smaller for the positive decisions, this indicates the existence of a decision threshold.

7.5 Learning

Learning is an essential part of many decision theories (Newell & Simon, 1972). One observes that decisionmakers learn from past decisions. This could be due to:

- better estimation of the effects of decisions
- adjusting the objectives after experiencing the effects of past decisions
- getting more routine in decisionmaking.

Of course, the adjustment of the objective function as a part of the learning process is a serious threat for deriving the particular objective function. However, one can introduce adjustment parameters, due to the learning process or one can split up the decisions over a longer period in two subperiods.

Moreover, there may be clear and well known reasons for adjusting the objective functions (children in a family, new government in a democracy, etc.)

7.6 Power Relations

Within a decisionmaking framework, there can be more units who contribute to the final decision, such as:

- different members in a family
- management, labor and capital in a firm
- diffèrent units within the government.

Knowledge of positions before decisions are made, make it possible to derive different objective functions for the different units. A second step is to derive power relations from initial positions and final decisions. For two units, it might be a straight forward procedure. For more units, a game theoretic approach seems useful.

8. DISCUSSION

Decision based economic theory (DEBET) is a methodology that inverts some procedures which are common in economic research. Normally one starts from an objective function or preference relation and derives testable relations on economic behavior. DEBET turns around this procedure and starts from observed decisionmaking and derives the underlying objective function. Only revealed preferences are used. However we assume and derive the underlying cardinal[10] objective function from these revealed preferences. This may seem confusing to the reader, used to established consumer theory (Deaton and Muellbauer, 1980, p. 51). But, the assumption of a cardinal or even an ordinal utility function, proved not to be essential in consumer theory. Starting from the existence of a preference relation, the same type of observable relations could be derived (Samuelson, 1983). This in no sense implies that consumers have no underlying

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[10] This implies that the objective function is unique upon a linear transformation.

cardinal utility function that directs their behavior. If economic research can be strengthened by postulating and measuring such functions, we should not use Occam's razor, which is a common "tool" in consumer theory (Kapteyn, 1977).

It is a different question under what circumstances such an objective function can be determined. Clearly, without any choice, one cannot reveal information. Economic agents should make decisions, to reveal information. When decisions are limited by constraints (e.g. budget constraints, available technology, etc.), this implies that only a part of the objective function can be derived from choice behavior. But this is quite common in economics: the same holds for production functions, demand functions, supply functions, etc. Mostly those parts are interesting from a practical point of view.

Although the present application of decision based economic theory is very limited, it is possible to discuss a number of strong and weaker points of the whole approach.

Beginning with the stronger points, the theory starts from a central element of economic theory: optimizing behavior of decisionmaking units (agents), each in a particular position (households, firms, government organizations, etc.). With this approach, one can test different theories about the form of the objective function(s) of economic agents. This can be done at the individual level and also at the more aggregate level.

A second point is that there is no preliminary requirement about the unit of measurement of the objective function and the type of variables which are used in it. The only restriction is that it should be objective variables of the decisionmaker. If it would be more useful to use a utility function of the household measured in characteristics of goods and services than in the quantities of goods and services, then one can use that particular function.[11] Moreover, there are no real preliminary restrictions on the objective function. One could incorporate:

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[11] The indirect utility function, measured in prices and income, cannot be measured directly. It could be obtained by combining "direct" utility functions with the budget restriction and Marshall demand functions (Deaton & Muellbauer, 1980, p. 38), which can be difficult at the individual level.

- Time in the framework of a household.
- Related elements to main decisions; such as the type of shop to buy goods, investment and loans (or to say it in the terminology used by economists: joint production and consumption can be handled.) The same holds about package deals in governmental organizations.
- Aspects of risk in the decisionmaking process; risk behavior can be an endogenous parameter of the objective function.
- Lifetime decisions about investment in human capital, etc.

Although each of the "difficult" areas in economic research might require some specific developments, there is no sign that these elements cannot be handled in the framework of DEBET.

A third point is that the theory can be applied easily with the present tools of economic analysis; linear programming and, if required, nonlinear programming. Moreover, restrictions on parameters can be introduced easily in such a framework.

Although the whole approach is strongly oriented on "individual" objective functions, decisions of a homogenous group of individuals could be amalgamated. Here, only a limited number of decisions for each individual can be required. Moreover, the assumption of identical individuals can be checked afterwards at the sub-group level.

A fifth point is that empirical results can be used in different fields of research (political economy, psychology, sociology, etc.). Although this method tries to find objective functions, this will not imply an explanation of why decisionmakers have such an objective function. Besides economics, several fields of research (see above) are concerned with explaining behavior of (economic) agents. If one can start from objective functions, then this facilitates theoretical developments and testing of theories in other areas.

Weaker aspects of this approach are:

- The definition of a decision. In many circumstances, it can be unclear what are particular decisions. Especially the negative decision might cause some trouble.
- The measurement of the effects of decisions can be rather difficult, especially the effects of package deals or a number of related decisions can cause a huge amount of work. Moreover, it can be necessary to interview the decisionmaker about the effects he/she had in mind: this can make the information unreliable.

- In its basic formulation, the theory makes no use of statistical methods. Because often theories are tested within a statistical framework, this makes it less easy to test alternative formulations of objective functions (see subsection 7.3).

At the present, we are looking for possibilities to apply the theory in the three main areas: households, firms, and the government. Only through experience can we learn how useful the conceptual framework is.

REFERENCES

Andersen, J.R., J.L. Dillon, and B. Hardaker (1977). Agricultural Decision Analysis. Iowa State University Press, Ames, Iowa.

Appelbaum, E. (1978) Testing Neoclassical Production Theory. Journal of Econometrics 7:87-102.

Arrow, K.J. (1966) Social Choice and Individual Values. New York, Wiley, second edition.

Burgess, D.F. (1975) Duality Theory and Pitfalls in the Specification of Technologies. Journal of Econometrics 3:105-121.

Burton, M. (1985) The Implementation of the EC Milk Quota. European Review of Agricultural Economics 12:461-471.

Chiang, A.C. (1984) Fundamental Methods of Mathematical Economics. New York: McGraw-Hill, third edition.

Commissie van de Europese Gemeenschap (1983) Gemeenschappelÿk Landbouwbeleid: voorstellen van de commissie. COM(83)500.

Cyert, R.M. and J.G. March (1963) A Behavioral Theory of the Firm. Englewood Cliffs:Prentice-Hall.

Deaton, A. and J. Muellbauer (1980) Economics and Consumer Behavior. Cambridge University Press, Cambridge.

Diewert, W.E. (1982) Duality Theory in Economics. North-Holland P.C., Amsterdam.

Frey, B.S. (1978) Modern Political Economy, Wiley, New York.

Fuss, M. and D. McFadden, eds. (1978) Production Economics: A Dual Approach To Theory and Applications. Volumes 1 and 2. North-Holland P.C., Amsterdam.

Hildreth, C. & G.J. Knowles (1986) Farmers' Utility Functions. In: Bayesian Inference and Decision Techniques, P. Goel & A. Zellner, eds. North-Holland P.C., Amsterdam.

Houthakker, H.S. (1950) Revealed Preference and the Utility Function. Economica 17:159-174.

Johansen, L. (1969) An Examination of the Relevance of Kenneth Arrow's General Possibility Theorem for Economic Planning. In: Collective Works of Leif Johansen, F.R. Forsund ed., Volume II, pp. 439-475.

Kapteyn, A. (1977) A Theory of Preference Formation. Thesis, University of Leiden.

Keeney R.L. and H. Raiffa (1976) Decisions With Multiple Objectives. New York:Wiley.

Krueger, A.O. (1974) The Political Economy of Rent-Seeking Society. American Economic Review 64:291-303.

Lopez, R. (1984) Estimating Labor Supply and Production Decisions of Self-employed Farm Producers. European Economic Review 24:61-82.

Newell, A. and H.A. Simon (1972) Human Problem Solving. Englewood Cliffs:Prentice-Hall.

Officer, R.R. and A.N. Halter (1968) Utility Analysis In A Practical Setting. American Journal of Agricultural Economics 50:257-277.

Oskam, A.J. (1983) Beleid in de EG-Zuivelsector. In: Ecomie en Landbouw, A.A.P. van Drunen, et al., eds. 's-Gravenhage: VUGA, p. 55-82.

Oskam, A.J. (1987) Principles of EC Dairy Policy, Wageningen, (mimeo).

Peltzman, S. (1976) Toward A More General Theory of Regulation. Journal of Law and Economics 19:211-240.

Pope, R.D. (1980) The Effects of Production Uncertainty. In: Operation Research In Agriculture and Water Resources, D. Yaron and C.S. Tapiero, eds., pp. 123-136. North-Holland P.C., Amsterdam.

Robison, L.J. & P.J. Barry (1986) The Competitive Firm's Response To Risk. Macmillan, New York.

Samuelson, P.A. (1983) Foundations of Economic Analysis. Cambridge: Harvard University Press, enlarged edition.

Simon, H.A. (1978) Rationality As Process and As Product of Thought. American Economic Review 68:1-16.

Srinivasan, V. & A.D. Shocker (1973a) Linear Programming Techniques for Multidimensional Analysis of Preferences. Psychometrika 38:337-369.

Srinivasan, V. & A.D. Shocker (1973b) Estimating the Weights for Multiple Attributes In A Composite Criterion Using Pairwise Judgments. Psychometrika 38:473-493.

Stiglitz, J.E. (1985) Information and Economic Analysis: A Perspective. Economic Journal 95:21-41 (Conference papers supplement).

Theil, H. (1964) Optimal Decision Rules for Government and Industry. Amsterdam: North Holland P.C.

Tinbergen, J. (1952) On The Theory of Economic Policy. North-Holland P.C., Amsterdam.

Van Herwaarden, F.G. and A. Kapteyn (1981), Empirical Comparison of the Shape of Welfare Functions. European Economic Review 15:261-286.

Van Praag, B.M.S. (1968) Individual Welfare Functions and Consumer Behavior. North-Holland P.C., Amsterdam.

Van Praag, B.M.S. and A. Kapteyn (1973) Further Evidence on the Individual Welfare Function of Income: An Empirical Investigation in the Netherlands. European Economic Review 4:33-62.

Varian, H.R. (1982) The Nonparametric Approach to Demand Analysis. Econometrica 50:945-973.

Varian, H.R. (1984) Microeconomic Analysis. Norton, New York, second edition.

APPENDIX A

Short description of the policy measures analyzed in section 6:

(1/2) The decision to introduce the super levy on April 1, 1984, were taken for a period of five years. Since this arrangement was also preferred in the short-term, two periods are examined. The effects are compared with unmodified policy.

(3/4) By introducing the super levy, a deliberate decision was make not to decrease prices. The effects, both for 1984 and for the period 1984-1988 are also computed here.

(5) In 1984 it was decided to fix quotas at a level of 1981 +1 percent. The quotas were set 1 percent higher, but at the same time the co-responsibility levy was increased by 1 percent.

(6) The buy-out program of the community covered 2 percent of the quotas in 1987/88 and 1 percent in 1988/89. Both programs are taken together. The effects are determined for the period 1987/1992.

(7) The suspension of quota (4 percent) with income compensation in 1987/88. The income compensation is in accordance with the agreements made.

(8) The additional suspension of quota (1.5 percent) with similar income compensation.

(9) The equivalent intervention price for milk was increased by 1.5 percent.

(10) The actual intervention prices of butter and skimmed milk powder were decreased 2 percent by using lagged payment for intervention products.

(11) In 1986/87, compared with 1985/86, an increase of intervention prices (with 1 percent) was not introduced.

(12) The intervention prices fell by approximately 2 percent because of new intervention regime.

(13/14) The co-responsibility levy was not increased to 3 percent or decreased to 1 percent during the period 1985-1987.

(15) In 1985, export refunds were again increased by approximately 10 percentage points.

(16) In 1986, export refunds were again increased by approximately 15 percentage points.

(17) In 1979/80, a Christmas butter campaign was carried on for 157,000 tons of butter; subsidy percentage (=s) of 30.5 percent; displacement factor (=df) of 0.7. The calculation compared these sales with external EC sales.

(18) The Christmas butter campaign of 100,000 tons was cancelled in 1980/81, with s=30 percent and df=0.75. The calculation was done with respect to external EC sales.

(19) The Christmas butter campaign of 120,000 tons in 1982/83; s=37 percent df=0.75; calculated with respect to external EC sales.

(20) The Christmas butter campaign of 120,000 tons was cancelled in 1983/84. Here it was assumed: s=40 percent; df=0.8 and the calculation was done with respect to external EC sales.

(21) The Christmas butter campaign of 1984/85 with 200,000 tons was coupled to the special sales of 200,000 tons of butter to the USSR. Now, the calculation was done with s=50 percent; df=0.8 and the price for sales to the USSR was 10 percent of the intervention price. The calculation was done with respect to longer storage and sales for animal feed.

(22/23) The Christmas butter campaign of 200,000 tons (s=50 percent; df=0.825) was cancelled in 1985/86; the calculation compared with sales for animal feed.

(24) During the period 1980-1987, a minimum of 150,000 tons of butter was put on the market via special sales to bakers, ice-cream manufacturing, social institutions, etcetera. These sales of 150,000 tons (s=60 percent; df=0.5) were compared with special exports (70 percent) and sales for animal feed (30 percent).

(25) In 1983 and 1984, an increase in special sales (see 24), by 100,000 tons in both years, was abandoned. In this case, s=65 percent; df=0.5 and a comparison was made with special exports (70 percent) and animal feed (30 percent).

(26) In 1985 and 1986, special sales were increased by a total of 225,000 tons; with this s=65 percent; df=0.5. Comparison was made with respect to special exports (50 percent) and animal feed (50 percent).

(27) In 1986 and 1987, 500,000 tons of butter were sold to the USSR. Special GATT permission was needed for this. Comparison was made with respect to sales of animal feed.

(28) In this arrangement, the total sales of special butter in the EC and the Christmas butter campaigns in the EC during the period 1980-1987, were compared with uniform price reduction for all butter.

The calculated effects of the variables 4, 5, t and 7 were expressed in ECU's of 1983.