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A dime for a jet, a quarter for a bridge

On some recent contributions to the theory of public goods

by G. P. de Bruin

Introduction

In the last ten years there has been a striking resurgence in the study of public goods allocation. The momentum for this research has come from the rediscovery by Samuelson and others in the '50's of the 'free-ridership' property inherent in these goods. It is the purpose of this paper to review and evaluate the most prominent results of these studies. To set the stage we start in the first section by giving a short overview of the development of the theory of public goods up to and including the work of Samuelson. In section 2 we introduce the basic game-theoretic and organizational concepts essential for the analysis of the allocation mechanisms in sections 3 and 4.

1. Some historical notes on the theory of public goods

It is the bulk of the older economists rather than the greengrocers who always considered to be apples and pears all there is in an economy. We are anxious to say the bulk and not all of the older economists. Indeed, there is the long-standing field of Public Finance the students of which have been concerned with the nature of collective wants, the determination of their output and the ways of financing them.

Around 1900 this branch of economics flourished.[1] With the development of marginal utility analysis the old debate between the 'ability-to-pay' principle and the 'benefit' approach of financing came to an end in favour of the alter. The peculiar characteristic of collective wants or public goods was delineated in that period by Mazzola as their indivisibility, i.e. the same amount must be consumed by all. The maxim of utility maximization required, so he concluded, that the consumer should equate the marginal utility derived from his outlays, both public and private. This would imply that all consumers paid a different price according to their own valuation (26, p. 44).

Knut Wicksell in his 'A New Principle of Just Taxation (45, pp. 72-118), however, gave a death blow to Mazzola's principle of tax policy:

'If the individual is to spend his money for private and public uses so that his satisfaction is maximized, he will obviously pay nothing whatsoever for public purposes ... Whether he pays much or little will affect the scope of public services so slightly, that for all practical purposes he himself will not notice it at all ... The utility and the marginal utility of public services (Mazzola's public goods) for the individual thus depend in the highest degree on how much the others contribute, but hardly at all on how much he himself contributes' (44, p. 81/82).

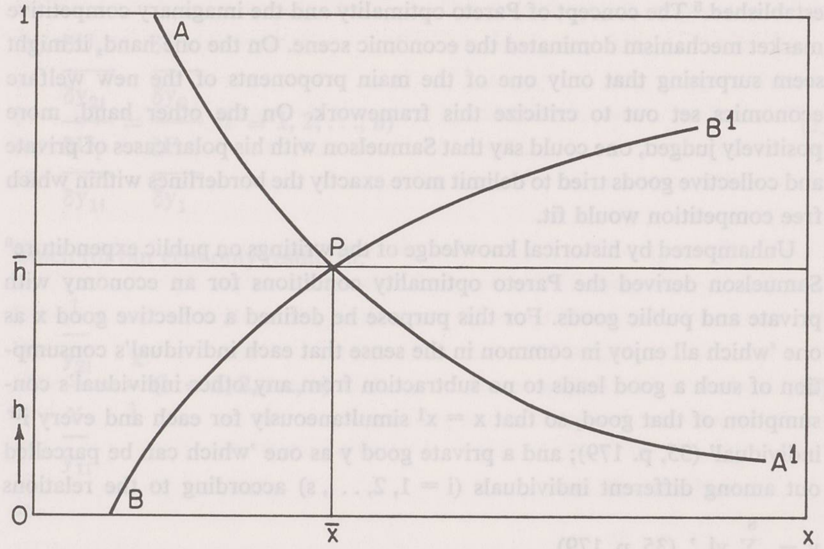
In this critique of Mazzola's analysis Wicksell indicated the awkward phenomenon of collective goods that half a century later would be nicknamed 'free-ridership'. In view of the necessary failure of market-like mechanisms Wicksell propounded that expenditures on public goods should be voted upon in Parliament in conjunction with specific cost distributions; and their adoption should be subject to the principle of voluntary consent and (approximate) unanimity. The requirement of near unanimity was inspired by the idea that 'it would seem to be a blatant injustice if someone should be forced to contribute towards the costs of some activity which did not further his interests or may even be diametrically opposed to them' (45, p. 89).

Wicksell's concern for the case of a collective good that could be a collective bad for some individuals looks praiseworthy and has been unjustly ignored most of the time in more recent analyses for the sake of convenience. What Wicksell seems to have overlooked, however, is that as soon as one gives up complete unanimity there might be an opportunity for an individual or a coalition of individuals of secure a more favourable decision by strategic voting, especially if the order of votes on proposals is a priori given.

The ultimate version of the benefit approach to public expenditure is to be found in the doctoral dissertation of Erik Lindahl published in 1919. Although more than twenty years had elapsed since Wicksell had pointed to the possibility of 'free-ridership', Lindahl's contribution consisted in fact of a voluntary exchange model in a partial equilibrium setting.[2] Simplifying the analysis to the case of two parties or individuals Lindahl set out his model by means of the diagram (21, p. 170)[3] on p. 435.

The curve AA^1 relates the amount of the public good party or individual A would desire, to the share, h, of the total costs that must be shouldered by this party. The plausible idea that the smaller the share of public expenditure imposed on group A, the greater will be that group's desire for public expenditure is expressed by the downward slope of the AA^1 curve in a way similar to an ordinary demand curve. The curve BB^1 depicts the same relationship between amount and cost share of the public expenditure for party B where the cost share for B is given by 1–h.

Lindahl argued that – assuming the existence of equal power and ability 'to



defend its own interests' for A and B (22, p. 171) – by bargaining, the parties would arrive at the solution or equilibrium P, the intersection point of both demand curves, corresponding with the cost shares $\bar{h}$ en $1-\bar{h}$ and the amount $\bar{x}$ of the public good. Being an intersection point of demand curves the tax share (price) for each party would, by the definition of a demand curve correspond to their evaluation of the public expenditure. Moreover, the money value of the net gain which both parties together derive from public activity, so noted Lindahl, is maximized at this equilibrium point (21, p. 172).[4] This is as far as Lindahl could go in the partial equilibrium context, but in fact in a note he added that if the income distribution could be regained as just the overall satisfaction of wants of all individuals in *utility* terms would be maximized (22, 172 n).

It is obvious, e.g. from references to Marshall's work, from terminology and from assumptions like 'equal power', that Lindahl considered this price formation process for collective goods to be similar to that of the competitive market for private goods. Of course, this overlooks the Wicksellian point that the individual, if left to his own devices will contribute nothing to public services, and so will not act like a price-taker in the competitive market. But it would be another forty years before Samuelson could again give preponderance to Wicksell's view.

At the time Samuelson published his 'Pure Theory of Public Expenditure' the stage of economic science had definitely changed. The partial equilibrium approach had been given away for general equilibrium analysis and the two Fundamental Theorems of the New Welfare Economics had been firmly established.[5] The concept of Pareto optimality and the imaginary competitive market mechanism dominated the economic scene. On the one hand, it might seem surprising that only one of the main proponents of the new welfare economics set out to criticize this framework. On the other hand, more positively judged, one could say that Samuelson with his polar cases of private and collective goods tried to delimit more exactly the borderlines within which free competition would fit.

Unhampered by historical knowledge of the writings on public expenditure[6] Samuelson derived the Pareto optimality conditions for an economy with private and public goods. For this purpose he defined a collective good x as one 'which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtraction from any other individual's consumption of that good, so that $x = x^i$ simultaneously for each and every i^{th} individual' (35, p. 179); and a private good y as one 'which can be parcelled out among different individuals (i = 1, 2, . . ., s) according to the relations $y = \sum_{i=1}^{s} y^i$ ' (35, p. 179).

Rather than follow Samuelson in the derivation of the optimality conditions for the more general cases, we will consider two specific cases of simple economies, one with two private goods and one with a public and a private good, for n consumers.

Case 1 – Suppose an economy in which the initial distribution of income is in terms of the private good y_1. There is, however, the possibility to produce a second private good, y_2, 'from' y_1 according to the linear production function $y_2 = \frac{1}{k} . y_1$ of $F(y_1, y_2) = k . y_2 + y_1 = 0$ $(k > 0)$. In words, by giving up k units of y_1 1 unit of y_2 can be 'produced'. Furthermore, we assume the n individuals to have identical utility functions, $U_i = \gamma . \ln y_{1i} + \ln y_{2i}, \gamma > 0$ in which y_{1i} en y_{2i} represent the consumed quantities of good y_1 and y_2 by individual i (i = 1, 2, . . ., n).

The Pareto optima for this economy can be found by maximization of the individual utility function of one individual e.g. U_1, give a fixed level for the other utility functions and given the production function $F(y_1, y_2)$. So, max! $U_1 = \gamma . \ln y_{1i} + \ln y_{2i}$ subject to the constraints $U_i = \gamma . \ln y_{1i} + \ln y_{2i} = U_i^0$ (i = 2, . . ., n) and $F(y_1, y_2) = k . y_2 + y_1 = 0$. Differentiation and elimination of the Lagrange multipliers brings about the following necessary condition for a Pareto optimum:

$$\frac{\dfrac{\delta U_i}{\delta y_{2i}}}{\dfrac{\delta U_i}{\delta y_{1i}}} = \frac{\dfrac{\delta F}{\delta y_2}}{\dfrac{\delta F}{\delta y_1}} \quad (i = 1, 2, \ldots, n) \qquad (1)$$

which for our economy results in:

$$\frac{\dfrac{1}{y_{2i}}}{\dfrac{\gamma}{y_{1i}}} = \frac{k}{1} \quad (i = 1, 2, \ldots, n) \qquad (2)$$

or

$$\frac{y_{1i}}{y_{2i}} = k . \gamma . \quad (i = 1, 2, \ldots, n) \qquad (3)$$

In words, the general condition (1) for a Pareto optimum can be circumscribed as that the *marginal rate of substitution* between the two goods for each individual should be equal to the *marginal rate of transformation.*

When the initial incomes, $\omega_i (i = 1, \ldots, n)$, for all n individuals are given, the specific Pareto optimal consumption-quantities corresponding to this income distribution can be determined for each consumer from (3):

$$y_{2i} = \frac{1}{k(\gamma+1)} \omega_i \qquad (i = 1, 2, \ldots, n) \qquad (4)$$
$$y_{1i} = \frac{\gamma}{(\gamma+1)} \omega_i$$

Now the interesting aspect of this case is that if we would extend condition (1) with a price ratio for the two goods:

$$\frac{\dfrac{\delta U_i}{\delta y_{2i}}}{\dfrac{\delta U_i}{\delta y_{1i}}} = \frac{p_2}{p_1} = \frac{\dfrac{\delta F}{\delta y_2}}{\dfrac{\delta F}{\delta y_1}} \qquad (1')$$

the same result as in (4) could have been obtained in our simple economy, if each individual would maximize his utility separately subject to the budget constraint: $p_2 \cdot y_{2i} + p_1 \cdot y_{1i} \cdot \omega_1$.[7]

This is the famous 'invisible hand'-adage of Adam Smith: when the consumers take prices as given, individual and independent maximization behavior will lead to a social (Pareto) optimum.

Case 2 – To keep as close as possible to the private goods case, we just replace the private good y_2 by a collective good, x. So we maximize $U_1 = \gamma . \ln y_{1i} + \ln x$ subject to the constraints $U_i^0 = \gamma . \ln y_{1i} + \ln x$ (i = 2, . . ., n) and $F(x, y_1) = k . x + y_1 = 0$.

This gives the following necessary condition for a Pareto optimum in an economy with one private and one public good:

$$\sum_{i=1}^{n} \frac{\frac{\delta U_i}{\delta x}}{\frac{\delta U_i}{\delta U_{1i}}} = \frac{\frac{\delta F}{\delta x}}{\frac{\delta F}{\delta x_1}} \qquad (5)$$

In words, the *sum* of the marginal rates of substitution for both individuals has to be equal to the marginal rate of transformation. For our specific economy we get:

$$\sum_{i=1}^{n} \frac{\frac{1}{x}}{\frac{\gamma}{y_{1i}}} = k \qquad (6)$$

or

$$\sum_{i=1}^{n} \frac{y_{1i}}{x} = k . \gamma \qquad (7)$$

Given these constraints and the initial incomes, ω_i (i = 1, 2, . . ., n), the optimum quantity of the collective good would be

$$\frac{\sum_{i=1}^{n} \omega_i}{k(\gamma+1)}$$

to be consumed by all individuals together and the optimal quantity of the private good for consumer i:

$$y_{1i} = \frac{\gamma\ \omega_i}{(\gamma+1)}$$

So, as Samuelson remarks (35, p. 182/183), a solution 'exists'; the problem is how to 'find' it: '. . . no decentralized pricing system can serve to determine optimally these levels of collective consumption'. This becomes clear from a comparison of condition (1) for the two private goods case and condition (5) for the one public, and one private good case. The essential difference is the *summation* of marginal rates of substitution in condition (5). Adding a price ratio, $\frac{p_x}{p_{y1}}$, would not be of much help in the public good case, because p_x should be nothing else than the *sum* of the individual contributions for a unit of the collective good, i.e. $p_x = \sum_{i=1}^{n} p_{x_i}$. Of course, as soon as we know the individual utility functions, we could determine these individual contributions, p_{x_i}, from the equation

$$\frac{\frac{\delta U_i}{\delta x}}{\frac{\delta U_i}{\delta y_{1i}}} = \frac{p_{x_i}}{p_y} \qquad (8)$$

but as it is in the self-interest of each person to hide his true preferences and to pretend to have less interest in the consumption of the collective good than he really has, one will never be able to assess the true individual contributions. Here we have again, in a (simple) general equilibrium context, the phenomenon of 'free-ridership' as sensed by Wicksell.[8]

Given that the market mechanism is destined to fail, what other allocation mechanism for public goods would Samuelson think of? His position is somewhat ambiguous. On the one hand there are some clues in the conclusion of his 1954 article that a voting process should do the job.[9]

On the other hand he refers in his 'Aspects of Public Expenditure Theories' (36) to the possibility of 'finding new mechanisms of a better sort' (than the market mechanism or political decision processes, GdB). Anyway, in his 1969 article 'Pure Theory of Public Expenditure and Taxation' he is hitting hard at the proponents of voting: '. . . it is striking how Wicksell and Lindahl and even Musgrave and Johansen..., after getting a gilmpse of pseudo-equilibrium, descend to the swampland of mathematical politics, ending up with inconclusive behaviour patterns by legislatures, factions and parties, inevitably running foul of Arrow's Impossibility Theorem' (37, p. 106).

Political scientists who are frustrated by this attack on their profession may be consoled by the fact that they share Samuelson's inferno with the game theorists: 'Game theory, except in trivial cases, propounds paradoxes rather than solves problems. It is possible that Professors Harsanyi or Bishop could apply advanced game theory – Nash threat points, etc. – to the problem of how two or more consumers of public goods will actually interact; even if one has doubts about the axioms of such models, the fruit of such an exercise might be of some interest. But I am not aware that those who are fascinated by the benefit notion have done much work in this area' (36, p. 106). Again, however, there is at the end the reference to the possible discovery of satisfactory mechanisms in the future: 'My doubts do not assert that passably good organisation of the public household is impossible or unlikely, but merely that theorists have not yet provided us with much analysis of these matters that has validity or plausibility' (37, p. 107).

As a matter of fact, although one can dispute their validity and/or plausibility, we were provided in the '70's with a host of analyses of the allocation of public goods. Furthermore, despite the negative judgment of Samuelson, game theory has played – and continues to play – a prominent part in these recent contributions to public goods theory. One has to admit, however, that at that time Samuelson could hardly have been aware of the seminal work on the design of allocation mechanisms by Hurwicz which would give great impetus to the analysis of public expenditure.

Before embarking on the study of public good allocation mechanisms we will review their building blocks in gave theory, and Hurwicz' contributions in the next section.

2. Game theoretic concepts and the design of allocation mechanisms

Economic theory has been hampered, so noted von Neumann and Morgenstern in the introduction to their *Theory of Games and Economic Behavior* (30), by the use of inappropriate mathematical tools. Economies are depicted as consisting of many Robinson Crusoe's, each maximizing their own (utility of profit) function. But this approach disregards the interdependence of the actions of the participants of an economy. There are, it is true, situations one can think of, in which the consequences of interactions are negligible as in the case of a great number of participants basic to 'free competition'. Application

of the more conventional mathematical theory becomes possible in such cases. Game theory is designed to handle the situations where interdependence cannot be ignored. In a foreword to Shubik's *Strategy and Market Structure* (41), Oskar Morgenstern states baldly: 'The theory of games provides a model for economic behavior no matter what the market structure is. The logico-mathematical properties of the model are well understood, and it is amenable to computation and numerical analysis' (41, p. viii). Shubik himself is less euphoric as to the potentials of game theory: 'Game theory provides us with tools to construct useful models of competitive situations. In the case of two-person, zero- or constant-sum games it also provides a normative theory as to how to play. By doing so it is able to define a *value* for such games. This is not so for general non-zero sum games of for zero-sum games with more than two players. There are many theories concerning the solution of these games. Some appear to be reasonable when applied to one set of phenomena but not to another. The two main distinctions made are between *cooperative* and *non-cooperative* theories. . . . A distinction between cooperative and non-cooperative solutions to a game is not always easy or desirable to make' (41, p. 18).

In the above situation Shubick indicates the weak spot in the theory of games: except for two-person, zero-sum games the proposed equilibrium concepts can hardly be considered to be a solution in every case. Presumably, this is the source of Samuelson's negative judgment. The indeterminacy of a game is perhaps less striking in a cooperative context because of the multiplicity of possible coalitions than for the non-cooperative non-zero sum games we will be concerned with in the sequel.

Non-cooperative non-zero sum games as a separate category have been studied for the first time by John Nash (29).[10] The meaning of a non-cooperative is that no preplay communication is permitted between the players. A game is non-zero sum if there is no choice of utility unit and origin for each player so that the sum of the utility numbers associated to each outcome is zero. The equilibrium concept introduced by Nash for these games is a generalisation of the maximum-solution for two-person zero-sum games. Starting point is a n-person game in 'normal form': n players, each with a finite set of strategies. Each combination of n strategies – one for every player – ('n-tuple') leads to an outcome of the game. With every outcome each player associates a payoff, so corresponding to each player, i, $(i = 1, \ldots, n)$ there is a payoff function, π_i, which maps the set of all n-tuples of strategies into the real numbers. Each player is assumed to be 'rational' in the sense that, given two alternatives, he will always choose the one he prefers, i.e. the one with the larger utility.

If we denote the set of strategies for player i by S_i and distinct elements of this set by $s_i, t_i, \ldots$, an n-tuple $s = s_1, \ldots, s_n)$ of strategies is an *equilibrium* *point* according to the definition of Nash if for *every* player i:

$$\pi_i(s_1, s_2, \ldots, s_i, \ldots, s_n) \geqslant \pi_i(s_1, s_2, \ldots, t_i, \ldots, s_n)$$

i.e. if s_i maximizes his payoff *given* that the strategies of the other players are held fixed.

Nice as this definition may seem, there are some complications which make it difficult to accept the Nash-equilibrium point as a general solution for non-cooperative non-zero sum games. The main source of trouble is that, generally, a game may have many equilibria. Moreover, it might be that there exists a non-equilibrium outcome which yields higher payoffs to all players than the equilibrium outcome(s). A couple of simple examples for two-person games, with only two strategies for each player, may help to clarify these points.

Consider the following matrix of which the rows indicate the strategies for player 1, the columns those of player 2 and the cells contain the payoffs for both players.

		player 2	
		s_2	t_2
player 1	s_1	1,3	−10,−10
	t_1	−10,−10	1,3

As can easily be checked, there are two Nash-equilibria in this game: the combination of strategies (s_1, s_2) and $t_1, t_2)$. However, if player 1 chooses strategy s_1, striving for the equilibrium point (s_1, s_2) and player 2 strategy t_2, striving for (t_1, t_2), they will end up at (s_1, t_2) yielding the worst payoff for both. This illustrates the fact that equilibrium strategies are not *interchangeable* in non-zero games, i.e. if (s_1, s_2) and (t_1, t_2) are equilibrium parts of strategies, this does not imply that (s_1, t_2) of (s_2, t_1) is.

In the example above the payoffs for the players are the same in both equilibrium points, but even that is not the general rule as may be seen when interchanging the payoffs for the players in the upper left cell. After such a change (s_1, s_2) en (t_1, t_2) are still equilibrium pairs but they yield different payoffs to each player.[11]

One would guess that all evils would be remedied if by properly delimiting the strategy sets uniqueness of equilibrium could be assured. This would e.g. be the case if each player would have a *dominant* strategy, i.e. a strategy which provides a response at least as good as any other strategy against all the strategies of the other player(s). Even then, however, there could arise an annoy-

ing flaw: no-Pareto-optimality of the equilibrium outcome. The two-person Prisoner's Dilemma game is perhaps the most famous example of a game with a unique, but Pareto-inferior equilibrium point[12]:

		player 2	
		s_2	t_2
player 1	s_1	5,5	0,10
	t_1	10,0	1,1

Strategies t_1 and t_2 are dominant for player 1, resp. 2; (t_1, t_2) is the unique Nash-equilibrium point but is Pareto-inferior (s_1, s_2).

As may be inferred from the above given examples, the assumption of rationality is in general an inadequate guiding principle of behavior for an individual taking part in a non-cooperative non-zero sum game. Either one should give a more specific definition of rational behavior or try to delimit one way or another the analysis to subclasses of games which are not prone to the problems mentioned above. The first approach has been followed by authors like Schelling (39), and especially Farquharson (7) in his remarkable analysis of voting procedures. Students of resource allocation mechanisms to which we now turn, have mainly taken the alternative road.[13]

The study of resource allocation mechanisms has once been described by the initiator and main contributor, Leonid Hurwicz, as a step toward synthesis of the analytical and institutional approach in economics (17, p. 3). While traditional economic analysis treats the economic system as one of the givens, the designer of resource allocation mechanisms regards the structure of the economic system as an unknown. Reiter, another important contributor, has labelled this approach in which the focus is not merely one of evaluating alternative allocations in a given economy, but of comparing the functioning of alternative systems operating in a class of economic environments, the (New)[2] Welfare Economics (31, p. 226).[14] An economic environment is defined by the initial resource endowment, technology and individual preferences, i.e. a set of circumstances that cannot be changed by the designer of the mechanism or by the agents (participants). An economic system can be conceived as a set of institutional or behavioral rules and can be modeled as a mechanism or adjustment process characterized by a language or specified set of messages, a set of response rules, and an outcome rule.

The functioning of the mechanism can be thought of as existing of two stages: a period of dialogue without action is followed by decisions about resource flows (production and exchange). The dialogue is an exchange of messages between participants. The nature and contents of the messages vary from mechanism to mechanism. They may be proposals of actions, bids, offers, etc. or they may contain information about the environment. The response rules specified by the mechanism determine the way current messages may be governed by messages previously received. When the dialogue stage comes to an end, the final message is translated into action according to the outcome rule.

This dynamic process is of course strongly reminiscent of and, as we may take for granted, greatly inspired by, the Walrasian tatonnement process for perfect competition. In fact, the price mechanism can easily be interpreted in terms of a resource allocation mechanism if we assume that there is an *auctioneer*, a disinterested (n+1) *st* agent, whose response function calls for price changes proportional to aggregate excess demand. The response functions of the other n participants in the economy require them to convey their excess demands given the prices called out by the auctioneer. This 'dialogue' will go on until equilibrium is somehow established, i.e. everyone is repeating his previous message. Then the outcome rule is to carry out exchanges according to the equilibrium bids made (17, p. 21).

One should realize, however, that this concept of a resource allocation mechanism without any further qualification would prove to be an empty shell. It is possible, indeed, to devise a mechanism, similar to the one above, for Samuelson's pseudo-market with public goods.[15] In this Lindahl mechanism, as it has been called, the auctioneer announces to each player a personal price p_{xi} for the public good, subject to the conditions

$$p_{x_i} \geqslant 0 \ (i=1, \ldots, n) \text{ and } \sum_{i=1}^{n} p_{xi} = k \text{ (in units of private good } y_1)$$

Consumer i, supposed to treat the price p_{xi} as a given parameter, will choose his public good demand x_i so as to maximize his utility

$$u_i(\omega_i - p_x x_i, x_i)$$

subject to the budget constraint $p_i x_i \leqslant \omega_i$ and to the non-negativity restriction $x_i \geqslant 0$. An allocation is generated only when the demands satisfy $x_1 = x_2 = \ldots = x_n$ in which case the public good is provided at that same commonly demanded level, and player i's private good allocation is $\omega_i - p_{xi} \cdot x$ (28, p. 66).

The insidious clause in the last paragraph is, of course, 'supposed to treat the price p_{xi} as a given parameter'. A self-interested consumer will certainly not. This indicates that in designing mechanisms we have to take into account the plausibility that participants will abide by the prescribed rules of behavior. In an economy with public goods, Wicksell and Samuelson noted, the *incentive-compatibility* of the mechanism – as Hurwicz has called it (17, p. 27) – is the real problem. The Lindahl mechanism yields Pareto-optimal allocations if the rules are followed. As the process is not incentive-compatible, however, we have to conclude that these desirable outcomes will never be attained. The central issue in the literature of the '70's on the theory of public goods has been the possibility of designing a public good allocation mechanism that yields Pareto-optimal outcomes and, at the same time, is incentive compatible.

For this purpose mechanisms have been modeled as n-person non-cooperative non-zero sum games, in which the sets of strategies exist of the response prescribed by the mechanism as well as other responses which would be more convenient to the self-interest of the participant. This 'cheating' by individuals openly violating the rules of the mechanism is conceivable if the other participants and/or any enforcing agency have no knowledge of their characteristics (preferences or endowment). As we have seen in an economy with public goods, an individual could try to cheat by doing what the rules would have required his to do had his characteristics been different from what they actually are, viz. pretending he is less eager for the public goods.

As we have set forth in the discussion of the theory of non-cooperative games, however, modeling a mechanism as such a game may evoke some ambiguity as to the appropriate solution concept. The most obvious approach would be to try to design a mechanism, yielding Pareto optimal outcomes, in which the true response is a dominant strategy for each participant. Indeed, the main body of recent literature on mechanisms for public goods is related to this approach. Unfortunately, Hurwicz (16) and Walker (44) have, independently, established that when public goods are present no allocation mechanism can always attain Pareto-optimal outcomes if it always provides each participant with a dominant strategy. It should come as no surprise, therefore, that the outcomes of the class of dominant strategy-mechanisms are all Pareto suboptimal. Nonetheless, some economists have hailed this kind of allocating process as 'an exciting new way of making collective decisions' (42, p. 3) and introduced the term 'demand revealing processes' for them (42, p. 3).

Other students, dissatisfied with the resulting inefficient outcomes, and with the severe limitations on the nature of the individual utility functions necessary to assure the existence of dominant strategies, have abandoned the dominant-strategy requirement and have sought to devise a mechanism in which the Nash equilibria are optimal. The main contribution in that area is by Groves and Ledyard (12). As we have discussed before, however, to prove the existence of an (optimal) Nash equilibrium is one thing, but the question of how that equilibrium is to be attained is quite another thing. The 'best' message of a consumer is dependent upon the messages of the other consumers, and some adjustment process is required.

In the next section we discuss the problems and merits of the demand revealing mechanisms; in a subsequent section those of the Groves-Ledyard approach.

3. Demand-revealing mechanisms

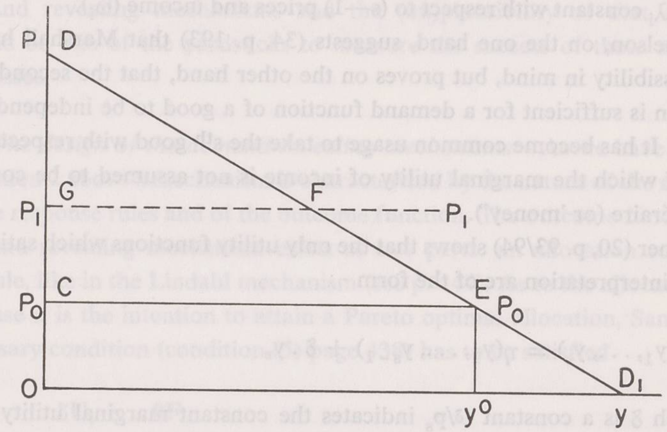
3.1. *Introductory remarks* – The main problem for a socially satisfactory allocation of public goods may be considered to be the pursuit of self interest by the participants in the economy: any mechanism based on voluntary exchange will fail to allow the individual to take account of the consequences of his behavior for the other consumers. It is therefore not surprising that, the most remarkable characteristic of a demand revealing mechanism is a tax rule that confronts the individual with the costs his behavior imposes on his fellow consumers. The ideal basic to this rule is as simple as it could be: if the 'fine' an individual should pay to compensate the losses in utility suffered by the other participants in the case of hiding his true preferences would surpass the extra benefits in terms of his own utility resulting from this strategic behavior, every incentive to 'free-ridership' would be gone. If, moreover, the resulting allocation would be Paraeto optimal, Samuelson's negativism would have been proved to be wrong.

Unfortunately, the simplicity of the idea is misleading. Firstly, to compute the losses and benefits referred to, one should knów the true preferences of the individuals. While this may seem to be an unsurmountable obstacle for further analysis along these lines, the problem can be handled by a slight change of scope as will be explained below. A second problem, however, is more difficult to overcome. It concerns the concept of a 'fine'. We used the word fine (as well as the quote marks!) deliberately because, as long as we renounce interpersonal comparison of utility, it is impossible to translate the utility losses of the other individuals without a medium like money into the utility of the manipulating individual.

By evaluating the utility losses of the different individuals in money terms, however, we open the box of Pandora which contains some of the nasty problems which are known in economic literature as compensation tests, index numbers and especially consumer surplus.

The concept of consumer surplus has been introduced by Marshall for the purpose of establishing a money measure for utility changes. Although there exist at least 5 different definitions of this concept nowadays (15), Marshall's definition is the most relevant for an analysis of allocation mechanisms. Therefore we will give in the next subsection a bird's eye view of Marshall's concept and the limitations on the nature of individual utility functions that it makes necessary.

3.2. *Consumer surplus and constant marginal utility of income* – Consider the situation an individual confronts at the market for some (private) good, which may be represented by the following diagram.



DD^1 indicates the individual's demand curve, p_0p_0 the (horizontal) supply curve, E the individual equilibrium position. At the price p_0 the individual will buy y_0 units of the good and pays p_0y_0 (or, in the diagram the rectangle $0y_0EC$) but, as Marshall remarked, he would have been prepared to pay much more, viz. $0y^0EP$). The difference what he has to pay and what he wants to pay, Marshall (25) considered to be the money measure for the net utility that for each such combination the (loss of) consumer surplus for the indivi-price of the good would be raised from p_0 to p_1, the are CEFG in the diagram could be taken to be the loss of consumer surplus – the money measure of the loss in utility – the price change would lead to.

As usual the diagram – or rather the partial equilibrium approach it represents – conceals the real problems. In general, the demand for a good is not only dependent on the price for that good, as suggested by the diagram, but also on the prices for other goods and on the income of the individual. Thus the demand curve's position is not unique, but different for every combination of income level and levels of prices for the other goods. But this would imply that for each such combination the (loss of) consumer surplus for the individual would be different! Marshall, being aware of this ambiguity in his concept, remarked that its use would make sense only in the case of 'constant marginal utility of income'. In an extremely succinct way Samuelson examined the meaning of that assumption (33). The foremost question concerns to which other variables the marginal utility of income should be or could be constant. In a general equilibrium context the 'marginal utility of income' for an individual i is nothing else than the Lagrange multiplier λ_i[15] which is itself a function of all prices and individual income, i.e. $\lambda_i = \gamma(p_1, \ldots, p_s, \omega_i)$. As a consequence

λ_i can never be constant with respect to all these (s+1) arguments, but at most with respect to s of them. Analytically, therefore, two different cases may be distinguished: 1 λ_i constant with respect to all prices, but *not* with respect to ω_i or 2) λ_i constant with respect to (s—1) prices and income (ω_i).

Samuelson, on the one hand, suggests (34, p. 193) that Marshall had the first possibility in mind, but proves on the other hand, that the second interpretation is sufficient for a demand function of a good to be independent of income. It has become common usage to take the s^{th} good with respect to the price of which the marginal utility of income is not assumed to be constant, as numéraire (or 'money').

Katzner (20, p. 93/94) shows that the only utility functions which satisfy the second interpretation are of the form

$$U(y_1, \ldots, y_s) = \eta(y_1, \ldots, y_{s-1}) + \delta \cdot y_s$$

in which δ is a constant (δ/p_s indicates the constant marginal utility of income) and $\pi(.)$ a function with the properties a utility function is usually credited with.[16] Katzner calls this kind of utility functions *quasi-linear* (in y_s). So for this kind of function the marginal utility of the numéraire good is a constant (δ).

Quasi-linearity of the utility function is a necessary condition for the absence of income effects, i.e. for the demand function to be independent of income; the absence of effects of prices p_j on the demand for good y_i ($i \neq j$, i, j = 1, ..., s—1), requires that the utilities of the goods $y_1, \ldots, y_{s-1}$ are *independent*, i.e. $\eta(y_1, \ldots, y_{s-1})$ can be written in additional form,

$$\eta(y_1, \ldots, y_{s-1}) = \eta_1(y_1) + \ldots + \eta_{s-1}(y_{s-1})$$

Only in the case of quasi-linear, additional utility functions

$$U(y_1, \ldots, y_s) = \eta_1(y_1) + \ldots + \eta_{s-1}(y_{s-1}) + \delta \cdot y_s$$

Marshall's consumer surplus has a univalent meaning. Furthermore, Samuelson (34, p. 201) proves that if and only if the utility functions have that form the different concepts of consumer surplus referred to above are the same.

Of course, the requirement of no income effects especially is a rather severe restriction. Indeed, one may suspect Samuelson of embarking on his lengthy proofs just for the sake of bringing the concept of consumer surplus into disrepute. His final judgment on the second interpretation of the 'constancy of marginal utility' assumption does not leave much doubt as to that: 'This means that any increase in income is spent completely on one commodity (namely

the numéraire, GdB). It need hardly be said that all empirical budgetary studies show this hypothesis to be absurd' (33, p. 85). Despite this negative judgment the absence of income effects is a sine qua non for the operation of demand revealing mechanisms and the (im)plausibility of that condition should be one of the yardsticks to measure the success of these allocation processes.

3.3. *The design of the demand revealing mechanisms* – As we have set forth in section 2 above a mechanism is characterized by the nature of the messages, of the response rules and of the outcome function. The outcome function of a demand revealing mechanism exists of two parts: an allocation rule and a tax rule, like in the Lindahl mechanism (see p. 444). As to the allocation-rule, because it is the intention to attain a Pareto optimal allocation, Samuelson's necessary condition (condition (5) page 438) has to be satisfied

$$\sum_{i=1}^{n} \frac{\dfrac{\delta U_i}{\delta x}}{\dfrac{\delta U_i}{\delta y_i}} = \frac{\dfrac{\delta F}{\delta x}}{\dfrac{\delta F}{\delta y}}$$

This condition turns out to be rather simple for all individuals in the case of quasi-linear utility functions. If we assume, as in the previous sections, that there is one private and one public good, the individual utility functions should be of the form $U_i(x, y_i) = v_i(x) + \delta_i y_i$ (i = 1, ..., n) in which x and y_i represent the public and the private good respectively and δ_i the constant marginal utility of the private good of individual i. Although, as the label suggests, a quasi-linear utility function is much more restricted as to allowable transformations than a fully ordinal scale, there is no problem whatsoever with a transformation such that $\delta_i = 1$ for each and every individual i. So we might read $U_i(x, y_i) = v_i(x) + y_i$ for the individual utility functions as well and in that case Samuelson's necessary condition takes a very simple form

$$\sum_{i=1}^{n} \frac{\dfrac{\delta U_i}{\delta x}}{\dfrac{\delta U_i}{\delta y_i}} = \frac{dv_i(x)}{dx} = \frac{\dfrac{\delta F}{\delta x}}{\dfrac{\delta F}{\delta y}} = \frac{k}{1} = k$$

if we postulate again a linear production function F(x, y) = kx + y = 0 (cf. Case 2, page 438). In words, the sun of the marginal utilities of x, in terms of the numéraire or money, y, should be equal to the marginal cost of x, in terms of y, k.

This condition will be satisfied if we take as the allocation rule the maximization of the total net consumers' surplus (again in terms of y), $\sum_{i=1}^{n} v_i(x) - k \cdot x$. We may assume that the 'government' or any central agency that has been attributed the task of coordinating the allocation process of the public good, has perfect knowledge of the production function, i.e. knows the exact value of k, but is dependent for information on the evaluation functions $v_i(x)$ on the messages of the individuals. In all variants of the demand revealing mechanisms the consumer are supposed to report their complete evaluation function. The extent to which they will follow this prescription is, of course, determined by the nature of their response rule and the tax rule.

We began the discussion on consumer surplus in the preceding subsection in view of the possibility of 'fining' a consumer for insincere demand revelation. We noted at that time that it would be very difficult to arrange a 'fine' for individual i which would compensate for the damage suffered by the other consumers as a consequence of his manipulative behavior, as this would require information about his real demand. With a slight change of scope, however, the idea of a 'fine' may be retained. The restrictions on the individual utility functions, i.e. the constant marginal utility of income hypothesis, assure the single-valuedness of the compensation. One can argue, namely, that individual i is responsible for the change in the optimal quantity of the public good and the concomitant total consumer surplus resulting from the transition of the situation in which the government maximizes the total net consumers' surplus for the (n—1) consumers with individual i excluded to that in which the total net consumers' surplus for all n consumers, individual i inclusive, is maximized.

To allow for the occurrence of misrepresentation of demand, we indicate the reported evaluation function with $w_i(x)$, reserving the symbol $v_i(x)$ for the true, or sincere function. The first situation referred to above can be represented, then, by

$$\text{Max!} \sum_{j \neq i} w_j(x) - k \cdot x$$

i.e. the government maximizes the (reported) total net consumers' surplus of all n consumers except individual i. Suppose, for the purpose of exposition, that the maximum is reached for a quantity $\hat{x}$ of the public good. This would imply that the total net consumers' surplus the (n—1) individuals concerned could share is equal to

$$\sum_{j \neq i} w_j(\hat{n}) - k \cdot \hat{n}$$

On the other hand, in the second situation the government would maximize

$$\sum_{j=i}^{n} w_j(x) - k \cdot x$$

Assuming this maximum to be reached for the quantity x* of the public good, the total net consumers' surplus of the (n—1) consumers other than individual i, is in this case $\sum_{j \neq i} w_j(n^* - k \cdot x^*$ if we forego for the moment a contribution to the costs by individual i. By definition the amount $(\sum_{j \neq i} w_j(x^*) - k \cdot x^*)$ is smaller than $(\sum_{j \neq i} w_j(\hat{x}) - k \cdot \hat{n})$. An obvious solution, therefore, would be to take the positive difference of these two sums as the 'fine' for individual i, and to incorporate the idea of a 'fine' in the tax rule by defining the tax for individual i, t_i, as

$$t_i(x^*) = (\sum_{j \neq i} w_j(x^*) - k \cdot x^*) - (\sum_{j \neq i} w_i(\hat{n}) - k \cdot \hat{n})$$

Thus defined the tax levied on each consumer is almost independent of his revealed preference. Indeed, the only way an individual can influence his tax share by the message to the government in through the optimal level x* of the public good. Nonetheless, one might wonder if with such a tax rule the mechanism would be 'incentive compatible', i.e. if it would be a dominant strategy for a consumer to report his true evaluation function. If so, $w_i(x) = v_i(x)$ for all i. We look at the individual's response rule for the answer.

In agreement with the hypothesis of self-interest the individual is supposed to respond or to conceive his message on the basis of maximization of the difference between benefits and costs. In other words, the consumer is assumed to maximize the term $(v_i(x) - t_i(x))$. Being informed on the content of the tax rule, the individual knows he has to maximize:

$$v_i x) - t_i(x) = v_i(x) - (\sum_{j \neq i} w_i(\hat{n}) - k \cdot \hat{n}) + (\sum_{j \neq i} w_i(x) - k \cdot x)$$

A necessary condition for a maximum is

$$\frac{dv_i(x)}{dx} - \frac{dt_i(x)}{dx} = 0$$

or

$$\frac{dv_i(x)}{dx} + \frac{d \sum_{j \neq i} w_j(x)}{dx} - k = 0 \qquad (1)$$

He also knows that the government maximizes

$$\sum_j w_j(x) - k \, . \, x$$

which leads to the condition

$$\frac{dw_i}{dx} + \frac{d \sum_{j \neq i} w_j(x)}{dx} - k = 0 \qquad (2)$$

Compasion of conditions (1) and (2) should persuade the consumer that the best thing to do – his dominant strategy – is to report truthfully and to choose $w_i = v_i$, irrespective of the choices made by his fellow consumers.

So, there really exist mechanisms for the allocation of public goods which are incentive compatible. In that sense the labeling of mechanisms with an allocation and tax rule as defined above by Tullock and Tideman as demand revealing mechanisms may be somewhat euphoric but is not incorrect. What about Pareto optimality of the outcomes? Unfortunately that requirement is generally not fulfilled. How could this be true, if the Samuelson condition is satisfied? Baldly stated it is because of the underdog position we have bestowed on the private good y. We have used the private good as a numéraire; all evaluations of the public good, benefits and costs, were in terms of y. We neglected the optimal distribution of the private good itself. To put it differently, the quasi-linearity of the individual utility functions entails that all potential Pareto optima in our one private, one public good economy involve one and the same quantity of the public good.[17] They differ with respect to the distribution of the private good. Whether the private good allocation is optimal depends on the initial income distribution, but for any such distribution Pareto optimality requires equality for each individual of the ratio of the marginal utility of public and private good on the one hand, and the ratio of the (individual) prices to be paid for both goods on the other hand. In the terminology used so far in this section the requirement would mean that the price paid per unit for the public good, e.g. p_i, by individual i should be equal to the marginal utility of the last unit of the public good, $\left.\frac{dv_i(x)}{dx}\right|_{x = x^*}$ both in

terms of the private good (cf. equation (8) at page 439 and the p_i's should have to sum to k, the price per unit of the public good in terms of y. For this to be true t_i should equal $p_i \, . \, x^*$ and so $\sum_{i=1}^{n} t_i = k \, . \, x^*$. In general, however, because of the nature of the tax rule $\sum t_i \neq k \, . \, x^*$, i.e. the government budget is unbalanced.

As to the tax rule referred to above, Loeb (23, p. 24-25) gives proof that it should always lead to a budget deficit. But as far as we can see, the proof contains an error, and the rule can lead to a deficit as well as to a surplus, dependent on the price of the public good. More important, however, is the fact that the rule does not assure a balanced budget. The question, therefore, is if it would be possible to design a tax rule that preserves incentive compatibility and yields a balanced budget.

Closer examination of the tax rule $t_i = (\sum_{j \neq i} w_j(\hat{n}) - k \, . \, \hat{n}) - (\sum_{j \neq i} w_j(x^*) - k \, . \, x^*)$ shows that the first component $(\sum_{j \neq i} w_j(\hat{n}) - k \, . \, \hat{n})$ does not play any part in the choice of optimal behavior for individual i, being determined completely by the revealed preferences of the other (n—1) consumers. This suggests that we could replace it by any other term without destroying the incentive compatibility property as long as that term is just a function of the reported evaluations of the other (n—1) individuals. If we use the generic form $h_i(w_{-i})$ for such a term, the class of tax rules which preserve incentive compatibility can be written as

$$t_i(x) = h_i(w_{-i}) - (\sum_{j \neq i} w_j(x) - k \, . \, x)^{18}$$

So the search for a balanced budget tax rule can be reformulated as the search for functions $h_i(w_{-i})$ such that

$$k \, . \, x = \sum_i t_i(x) \quad \text{or} \quad k \, x = \sum_i h_i(w_{-i}) - \sum_i (\sum_{j \neq i} w_j(x) - k \, . \, x)$$

After some algebraic manipulation this equality turns out to be equivalent to $\sum_i h_i(w_{-i}) = (n-1) \, k \, . \, x - (n-1) \sum_i w_i(x)$

Unfortunately, it can be proven that no such functions $(h_i(w_{-i})$ exist. More generally, Hurwicz (16) and Walker (44) have shown that it is impossible to design an allocation mechanism for public goods that has a dominant strategy for each individual and at the same time always yields Pareto optimal outcomes. This result implies that we either have to give up the dominant strategy property or Pareto optimality.

One reason to keep to dominant strategies – and the demand revealing mechanisms – might be the feeling that although Pareto optimality is not completely achieved, for some demand revealing mechanism – i.e. for some well chosen tax rule – it is always nearly so. It is in fact the position taken by Tullock & Tideman towards the Clarke or surplus revelation mechanism – a demand revealing mechanism with a tax rule such that there always is a budget surplus. They argue (42, p. 9) that the lack of budget balance is not a problem for the demand revealing process in the large number setting (i.e. in an economy with a large number of consumers, GdB) because the excess revenues will generally be a vanishingly small fraction of expenditure. The argument, however, is ill-founded as the evidence is restricted to some specific examples. Moreover the surplus has to be really wasted because any attempt to distribute it to the consumers will destroy the Samuelson condition.

A problem closely related to the surplus issue is what Groves & Ledyard (13, p. 16) call the 'bankruptcy problem': the tax burden may be too large for some consumer given his income. To put it differently, under a demand revealing mechanism a consumer is not guaranteed to be as well off as he could be if he lived on his initial endowment of the private good. In the language of game theory, the outcomes are not necessarily individually rational. As Groves & Ledyard (13, p. 118) remark: '. . . under these mechanisms a consumer's ownership rights over his initial endowment of private goods are limited and may, in fact, be essentially nonexistent. For this reason alone, one might expect a certain amount of reluctance on the part of consumers to accept such a mechanism as a method of allocating public goods'. The reason for the lack of individual rationality is, of course, exactly the same as why incentive compatibility is preserved: the disconnection of the subjective value of the public good for the individual and the amount of tax he has to pay for it. In mechanisms where equality of the two magnitudes is sustained, like the competitive or Lindahl mechanism, individual rationality is guaranteed.[19]

Tullock & Tideman who apparently like to be seen as the custodians of the demand revealing mechanisms estate, again put off the problem by arguing that in general the tax is extremely small (43, p. 126). This appears to be a silly argument because, although it may be true for the tax amount of one collective good, public expenditure in the modern welfare state amounts to more than 50% of average individual income. The hollowness of their argument is the more serious because they also base their defense of the zero income effects on it.

The plausibility of the zero income effects assumption is something we have already referred to in the section on consumer surplus. We quoted Samuelson who considered the assumption to be invalid. But opinions differ about this issue. In his 'The Rehabilitation of Consumers' Surplus' Hicks pleads for the

reasonableness of the 'constant marginal utility of income' hypothesis: 'If the marginal utility of money is constant, it implies that the consumer's demand schedules are unaffected by changes in his real income; all it need imply for this purpose is that the demand schedule *for this commodity* is unaffected (or substantially unaffected) by the changes in real income . . . It is in fact a very reasonable simplification, which is likely to be valid in most applications, though probably not in all. Whenever the commodity in question is one on which the consumer is likely to be spending only a small portion of his total income, the assumption of "constant marginal utility of income" can usually be granted; and it still can be granted, even if this condition is not fulfilled, provided the particular charge under discussion does not involve a large *net* change in real incomes' (15, p. 326). Time and place may have changed but Hicks and Tullock & Tideman are telling the same story. It is tempting to quote Samuelson once again. This time from his 'Foundations' in which he seems to attack directly the purport of the final sentence of the Hicks' quotation. 'Of course, no one has observed, and presumably no one ever will, a preference pattern in which all of extra income is spent upon one commodity. Note that this is not even approximately true for instantaneous rates of change ever when we neglect "second order of smalls"' (34, p. 194). Empirical evidence pro or con the zero income effect hypothesis for public goods should be better than words. Not much work has been done in this area, but the available studies indicate that income elasticities of demand for various public goods are significantly different from zero (3, 4).

If income effects are present, the demand revealing mechanisms will loose their dominant strategy theory property. The reason is that since any consumer's valuations of public goods depend on their income, their true valuation functions will have to depend on the messages of the other consumers. Dominant strategy equilibrium bygone, we are thrown back into the wilderness of non-cooperative games. More seriously, into that of non-cooperative games with incomplete information as nobody knows the valuation functions of his fellow consumers. Groves & Ledyard (12, p. 7) have shown that given some regularity of the individual utility functions correctly revealing the marginal rates of substitution by the consumers yields a Nash equilibrium. The question arises, especially because of the incomplete information, of how such an equilibrium is to be arrived at. Some type of adjustment process would be required in order to reach the Nash equilibrium. But, as Groves & Ledyard indicate (12, p. 120), given any type of adjustment process, two difficulties appear. First of all, the adjustment process may not converge. Secondly, a sophisticated consumer could strategically manipulate the outcome from this Nash equilibrium to a more advantageous outcome for himself.

Finally, leaving all these potential flaws aside, there remain three problems which question the feasibility of the mechanism: first, will any consumer be able to report his true valuation function even if he wants to. Second, will individuals have any incentive to invest time and effort in properly specifying their preferences. Third, the operation costs for the mechanism seem to be huge. Groves & Ledyard seem to point to the first problem when they note: '... the communication requirements of the government rules are undesirably complicated. Since the language M is a large space of functions, it contains some extremely complicated functions that would be difficult to imagine being communicated' (12, p. 174). We have to agree with these authors, provided 'difficult' is replaced by 'impossible'. But even if consumers could, why should they? Clarke who raises that point (5, p. 40), concludes that after all it may come out not as badly as it first seem. His argument is that the demand revealing process could lead to representative forms of organisation, and that well organized special interest groups would be motivated to invest in information designed to lead to correctly specified preferences. But, as he has to concede, 'in such a setting, many individuals would not participate, just as they rationally do not vote in a representative democracy. Such individuals would simply accept a 'benefit tax' representing their allocated benefit share of all public goods produced' (p. 41). The comparison with the act of voting looks as apt as it is unfortunate. Who is vote rationally? Who is abstaining rationally? What rationality are we actually talking about here? And if Clarke is so fond of interest group formation, he should also accept the possibility of manipulating the outcome by these groups or coalitions. It might also be of some interest that Bennett and Conn (2, p. 100) prove that a demand revealing mechanism which is group incentive compatible does not exist. But it is fairly evident that Clarke mitigates this aspect.

4. Alternative mechanisms

From our criticisms in the last section one may deduce that we disagree with Tideman's characterization of a demand revealing process, which appeared in the introduction of the special issue of Public Choice, as 'an exciting new way of making collective decisions. The feature that makes it so exciting is that it comes extremely close to the ideal of guaranteeing that collective decisions will be made efficiently' (42, p. 1). We think that it does not come near any ideal whatsoever. But which alternatives are available?

As we have noted already, one alternative might be to look for mechanisms which lack the dominant strategy property but fully yield Pareto optimal outcomes. Some work in this area has been done. The drawback of such mechanisms without dominant strategy equilibrium is that incentive compatibility has to be considered in terms of the weaker and more volatile concept of a Nash

equilibrium with which problems of attainability and of adjustment processes are generally associated.

Most prominent is a mechanism designed by Groves & Ledyard, initially called the Optimal Mechanism (12) and later the Quadratic Government[21] (11). It has some specific advantages compared with the Demand Revealing Mechanism. Firstly, the messages to be sent by the individual to the government are much more simple: it is just one number, positive or negative, indicating the increment (or decrement) of the public good the consumer would like the government to add (or subtract) to the amount requested by the others. Secondly, it does not require zero income effects. Thirdly, as indicated, the Nash equilibrium outcome, resulting from true revelation of preferences, is Pareto optimal.

In spite of these advantages the mechanism still entails one major difficulty of the Demand Revealing Mechanisms, as well as an added difficulty. Like those of the Demand Revealing Mechanisms, the outcomes of the Groves-Ledyard mechanism are not necessarily individually rational, i.e. the outcomes are not Lindahl allocations and there is still the problem of' bankruptcy'. The additional problem arises from the lack of the dominant strategy property. The best message of a consumer is dependent on the messages sent by the others. Ignorance of the others' preferences implies that the consumer has to learn about these utilities by 'trial and error' and that some type of an adjustment process is required. The individual response rule of the mechanisms prescribes 'competitive behavior' to the consumers, i.e. they have to take the messages sent to the government by other individuals as given. This assumption precludes, as Greenberg, Mackay and Tideman remark in their critique of the mechanism, the possibility that during the adjustment process a consumer could learn how other consumers react to his message and then take these reactions into account in determining his best message (10, p. 130).

Muench and Walker (28) have investigated the performance of the Groves-Ledyard mechanism when the participants engage in manipulative behavior. As we have explained in section 2 an n-person non-cooperative game may have many Nash-equilibria, some of which may be Pareto optimal while others are not. If we suppose that all n players practise manipulative behavior, the Groves-Ledyard mechanism defines such a non-cooperative game. The equilibria of this game which Groves & Ledyard have shown to be Pareto optimal are those involving 'competitive behavior'. Muench and Walker considered the Nash equilibria which involve manipulative behavior. Their findings seem rather hopeful: in large economics the manipulative Nash equilibria of the Groves-Ledyard mechanism are very nearly Pareto optimal. As they do not report, however, on the kind of manipulative behavior they have taken into account, the final evaluation of the mechanism's performance with respect to strategic behavior should wait till more evidence is available.

The trust in Groves & Ledyard's mechanism is anyhow seriously diminished by another finding of Muench & Walker: even under the required 'competitive behavior' of the participants equilibria may fail to exist in a large economy and/or participants may have virtually no incentive to act as utility-maximizers when they find themselves in a large economy (28, p. 74). Together with the potential violation of individual rationality these disadvantages reduce the attractiveness of the mechanism, in our opinion, to a minus level.

Mechanisms that produce Lindahl alternatives at Nash equilibria, i.e. individually rational ánd Pareto optimal allocations, have been devised by Hurwicz and Walker (11, p. 56-57). Hurwicz proposal is as yest unpublished, Walker's contribution has appeared recently in Econmetrica (44). With respect to manipulative behavior, the non-existence of equilibria and the potential instability of the outcomes of his mechanism has the same scores as Groves & Ledyard's.[22]

Epilogue

In the foregoing sections we have considered some recent contributions to the theory of public expenditure. The discussion has centered on the problem of combining incentive compatibility and Pareto optimality of the outcomes. The results of the alternative approaches are rather disappointing.[23] Satisfaction of both incentive compatibility and Pareto optimality, when we interpret incentive compatibility to require dominant strategies for the individuals, is impossible as has been proven by Hurwicz and Walker (c.f. p. 23). Moreover, we have criticized as rather unreasonable, the assumptions which have to be made with respect to the individual utility functions to secure the existence of dominant strategies. We may add that lack of space prevented us from analyzing the Groves-Ledyard mechanism as fully as the demand revealing mechanisms, but that even with their mechanism, (although the restrictions are less severe), the message space is such as to allow individuals only approximate report of their real public good valuation.

In view of the difficulties encountered when we strive to reach incentive compatibility and Pareto optimality simultaneously, there seems to be all the more reason to evaluate the necessity and/or attractiveness of both conditions again.

The emphasis on incentive compatibility in the recent contributions has been most strongly attacked by Leif Johansen: '. . . I feel that the present strong emphasis on the point (i.e. correct revelation of individual preferences about public goods, GdB) is somewhat misplaced. My main reason for thinking this is perhaps that I do not know of many historical records or other

empirical evidence which show convincingly that the problem of correct revelation of preferences has been of any practical significance' (19, p. 147). In his opinion the clue to the unimportance of the problem of misrepresentation of preferences lies in the existence of at least two tiers in the decision making system of Western democracies: the electorate chooses politicians who constitute a decision-making body, deciding on public goods and corresponding costs; according to him, the politicians have little or no opportunity to misrepresent their preferences in order to reduce the cost-shares levied on the groups they represent. The reason for this is mainly because their voters would not understand, and therefore, would not accept their 'free rider'-behavior.

Johansen does raise an interesting point here. Of course, if we limit our attention only to the voting process in Parliament, the impossibility of a Pareto optimal dominant strategy mechanism we referred to above, suggests the non-existence of any decision-making rule in which true revelation of preferences is a dominant strategy. Indeed, Gibbard (8) and Satterthwaite (38) have, independently, proven that no voting rule can satisfy this dominant strategy requirement unless it is dictatorial. Johansen does not deny this fact, but focuses attention on the preventive effect on strategic voting behavior of the two-stage character of representative democracy. The voters elect politicians 'who constitute a decision-making body, deciding on public goods and corresponding costs' (p. 149). It should be difficult for a member of Parliament in the case of strategic behavior to explain to his electors why he voted 'against' their interests.

The argument is still not as convincing as it first appears. For one thing, the relationship between 'representative' and 'his or her' electors is in general rather vague regardless of the election procedures. Moreover, members of Parliament have to justify their behavior only periodically, and empirical evidence suggests that the average voter has a short memory. In the third place, it is a somewhat gratuitous argument to say that one does not know of 'historical records or other empirical evidence' of misrepresentation of preferences in 'the decision-making system which decide on public goods and corresponding costs'. That is so because in practice the decision on 'corresponding costs' is limited to the total level of the expenditure and does not pertain to the individual shares. Concealment of true preferences, as we have noted earlier, can be expected in order to adjust the individual cost share favorably. However, in none of the existing economies are we aware of taxation exhibits of such a 'quid pro quo' character. In fact, every citizen is assessed for a part of total expenditure: while in public finance *theory* the benefit approach has become predominant, in every day practice the ability-to-pay-approach is still more common.

There are, after all, two important reasons for this difference between theory and practice of taxation. The first, and perhaps most important, is created by the problem of costs of information. Even in a representative system the costs entailed by deciding on each public outlay, and concomittant individual cost shares separately, would get out of hand. Indeed, anybody who is aware of the huge costs of referenda or even surveys, should realize that these amounts are the death-blow to the allocation mechanisms discussed above, irrespective of their performance.

The second reason is that in the theory of public expenditure, and especially in the more recent contributions on allocation mechanisms discussed above, satisfaction of both incentive compatibility and Pareto optimality of outcomes has been emphasized. The precedence of the rather elusive concept of Pareto optimality must for the main part be attributed to its prominent place in the perfect competition model which is still the decisive yard stick of the economists. Pareto optimality can at most be considered, however, as a necessary condition for a social welfare optimum.[24] For economic policy some criterion of interpersonal comparability of welfare or utility is required. The predominance of the 'ability to pay'-approach as effected by progressive tax schemes might be interpreted as a (be it vague and more or less implicit) way of bringing such a welfare criterion into existence.

Summarizing we could say that to a great extent we agree with Johansen's judgment of 'misplaced emphasis', although on different grounds. All resource allocation mechanisms for public goods which have been designed so far take the perfect competition model as a point of reference. Consequently the condition of Pareto optimality has been over-emphasized unjustly for two reasons. The first reason is the possible gap between Pareto optimality, and full or social welfare optimality, as just indicated. The second reason is perhaps even more substantial and relates to the fact that consumers are usually unable to report their utility functions, and so are unable to choose their individual optimal behavior. However, this is generally disregarded by economists as being too ackward. Even for the clever mathematicians among the consumers, it is only possible to compare a finite number of the potentially available alternatives. A realistic decision-making mechanism should take account of this fact. Descending the Olympus of abstract ideals and unwarranted optimal conditions, it will turn out, therefore, that the problem of satisfactory allocation of public goods is reduced to that of finding a socially acceptable decision-making rule, and of representative democracy.

Notes

1. An anthology of the main contributions can be found in Musgrave & Peacock's

indispensable *Classics in the Theory of Public Finance* (27). The works by Mazzola, Wicksell and Lindahl referred to in the text are included in this collection.

2. In the partial equilibrium approach of which Marshall can be considered to be the founder and most important proponent, the analysis is limited to the market for one good under a 'ceternis paribus'-assumption for the markets of all other goods. In contrast, the general equilibrium approach initiated by Walras, the functioning of all markets is analyzed simultaneously. We will come back to the pro's and cons of the partial equilibrium approach in a later section.

3. In fact the diagram as presented here is Lindahl's rotated over 90° in conformance with the usual practice nowadays to put the quantity of the good on the abscissa and price or cost on the ordinate. See Johansen (18, p. 131).

4. This 'money value of the net gain' is in fact Marshall's consumers surplus, a concept we will come back to in section 3. Incidentally, as original Samuelson most often is in his own contributions as difficult it seems to be for him to read carefully the contributions by others. In his 1969 survey article he remarks at p. 112 (37): 'It also happens to be true, what should not have impressed Lindahl as being important, that the total of money utilities summed over people, . . . is in this case at a maximum at the pseudo equilibrium of Lindahl'. From the quotation in the text may be inferred that Lindahl certainly did consider this an important result.

5. Arrow (1). The first fundamental theorem says that a competitive equilibrium allocation is Pareto optimal; the second that by an appropriate redistribution of income every Pareto optimal allocation can be effectuated by the competitive market mechanism. An allocation is Pareto optimal, if there is no alternative that makes some people better off and no one worse off.

6. As professed in his 1969 survey article (37).

7. Remember that we supposed to be the initial incomes in terms of y_1 only. The price ration p_2/p_1 would in our economy be equal to k.

8. Samuelson refers because of this phenomenon to the above equilibrium as a 'pseudo-general equilibrium' (37, p. 104).

9. 'To explore further the problem raised by public expenditure would take us into the mathematical domain of "sociology" or "welfare politics", which Arrow, Duncan Black and others have just begun to investigate' (35, p. 183).

10. Von Neumann & Morgenstern, assuming that with many participants there would always be an inclination to cooperate, left this category of games aside.

11. The possibility of different payoffs in equilibria is sometimes called the *non-equivalence* of the equilibrium payoffs.

12. The reader is referred to Luce & Raiffa (23, p. 34 ff) for a more extensive treatment of this game.

13. An even more extreme choice would be to alienate the Nash equilibrium as a solution concept for non-cooperative games. Some authors adhere instead to the maximin-solution.

14. In principle, such a comparison should also include the costs of operation. Due to ignorance as to that aspect of a system it is ignored most of the time. Particularly for the allocation mechanisms to be discussed below it seems to be a problem one should take seriously.

15. See Case 2, p. 438 ff. The assumptions of one public and one private good, of the initial endowments in terms of the private good and of the linear production function is adhered to, again, in what follows.

16. In a general equilibrium setting with s (private) goods $y_1, \ldots, y_s$ and prices $p_1, \ldots, p_s$ individual i maximizes his utility $U_i(y_1, \ldots, y_s)$ subject to the budget constraint $p_1 . y_1 + \ldots + p_s . y_s = \omega_i$, or $V = U_i(y_1, \ldots, y_s) - \lambda_i(p_1 . y_1 + \ldots + p_s . y_s - \omega_i)$ Then

$$\frac{\delta U_i}{\delta \omega_i} = \lambda_i\left(p_1 \frac{\delta y_1}{\omega \delta_i} + \ldots + p_s \frac{\delta y_s}{\delta \omega_i}\right) = \lambda_i \text{ (14, p. 34)}$$

17. E.g. First derivatives all positive, second derivatives negative. When discussing the mechanisms we will come back to the issue of relevant properties.

18. Of course headmaster Samuelson had observed this rather strange result long before. In the appendix of his 1969 survey-article he remarked: 'The generalised contact curve of multually tangent u^i contours (i.e. the set of Pareto optimal points, GdB) is seen to be vertical (in the Lindahl diagram cf. p. 435) in this case of constant marginal utility of the private good, . . .' (37, p. 112).

19. This class of tax rules, the allocation rule and the response rules stated above define the *class* of demand revealing mechanisms. This labelling is, however, not used by all authors on this subject, e.g. Green and Laffont (9) speak of Groves mechanisms. A theorem of Green & Laffont (9) establishes that any mechanism satisfying the dominant strategy property and the Samuelson condition in the case of quasi-linear utility functions is equivalent to a demand revealing mechanism.

20. This might be the right place to note that even in private goods economies incentive compatabilty could be a problem. In fact, there exists in general no resource allocation mechanism that yields individually rational, Pareto optimal outcomes which are also individually incentive compatible, for all participants. This impossibility theorem is true in the nicest of private goods economies, as well as when public goods are present. However, the incentives under the competitive mechanism for allocating private goods do improve as the economy grows, while the incentives on the public good side cannot be expected to improve and may well worsen as the number of agents increases (32, p. 360).

21. This name relates to the quadratic nature of the tax rule associated with the mechanism.

22. Drèze and de la Vallée Poussin (6) have devised a mechanism for public goods in wihch incentive compatibility is associated with maximin instead of Nash behavior for the participants. Essentially, the same problems we encountered in the Nash mechanisms discussed above are present with this mechanism.

23. We have deliberately left aside one major problem as it is in all of the literature concerned. The problem regards to the obivous fact that a collective good might be a collective 'bad' for some or many consumers. More it generally relates to the assumed regularity properties of the individual utility functions we referred to in a footnote above. It goes without saying that infringement of these would strengthen seriously the difficulties of existence and stability of optimal outcomes.

24. Sen, among others, has even disputed the acceptibility of Pareto optimality as a necessary condition for such an overall optimum (40, pp. 83-85).

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Jean Bodin and the concept of the 'liberal state'

by Norman Furniss

In the lexicon of political thinkers, Jean Bodin is usually accorded a prominent place in the second rank. This spot is given either because of his importance as a transitional figure between medieval and 'modern' modes of thought, or more specifically because of his elucidation of the interrelated concepts of 'sovereignty' and the 'state'.[1] Bodin has been credited, by himself and by others, with being the first theorist to posit sovereignty as the essential and unique element of the state. In the most arresting pages of his major work, *The Six Books of a Commonwealth* (1959), sovereignty is defined starkly as the 'most high, absolute and perpetual power over the citizens and subjects of a commonwealth' (p. 84) and operationalized as 'the power to give laws to all his subjects in general, and to everyone of them in particular, without consent of any other greater, equal, or lesser than himself' (p. 159).[2] From a study of these and other statements it is small wonder that it has been concluded that 'an absolute prince can do almost anything he desires' (Chauviré, 1911, 315) or, more completely, that 'an absolute king had full possession of all the powers that a state could legitimately exercise, and even if he overstepped the bounds of higher law, he could not be lawfully resisted or deposed' (Franklin, 1973, p. 92).

This perspective gives an adequate account of Bodin's specific notion of sovereignty and demonstrates how Bodin attempts to achieve his immediate purpose of confounding the Huguenot theory of resistance (see Skinner, 1978; Vol. II, p. 285). The difficulty in this perspective comes when one attempts to assimilate the numerous restrictions, exceptions, and exhortations that Bodin undertakes particularly beginning with Book Two of the *Six Books*. It is the presence of these restrictions that often is held primarily responsible for the lack of a certain 'timeless quality' in Bodin's work found for example in Hobbes (C. F. Cranston, 1974). For if some of the caveats (for example, the primacy of the Salic Law, any particular sovereign desire to the contrary) might be dismissed as remnants of Mediaevalism, and if the exhortations might be written off as ad hoc moralizing of which even Hobbes was known