Intergenerational Solidarity, Welfare and Human Ecology
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HOW TO SHOW INTERGENERATIONAL SOLIDARITY WITH RESPECT TO THE PHYSICAL ENVIRONMENT

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1. *An Important but Difficult Subject*

In our attitudes and policies concerning the physical environment, what does solidarity with future generations mean? Partha Dasgupta wants to set out the methodological approach used by economists in order to deal with the question. This is a good opportunity to refer more generally to the methodology of economics with respect to all questions which concern a long-term future and require a judgement about what ought to be done for the common good. My aim is here to provide an essentially literary introduction to the paper, putting it in a somewhat broader perspective.

Normative issues about the long term are objectively difficult, because in particular they involve more than a target to a distant future: they truly require dynamic programming under uncertainty; they will have to be implemented in a political context, which cannot be perfectly forecast, and so on. We economists are naturally led to decompose these difficulties, hence to proceed at various levels. A major decomposition consists in finding answers to three types of questions:

- Which principles must underlie the choice of objectives?
- What is really the context?
- Which procedures can be adopted for well articulating the principles with the knowledge of the context?

2. *In Search of a Choice Principle*

The paper deals with only the first question, which is, of course, crucial in our deliberations during this session. It pays a special tribute to Tjalling Koopmans and to his 64-page article discussed precisely here in 1963 within the activities of the Pontifical Academy of Sciences.

At the time there were twenty or so of us economists gathered to examine 'The Econometric Approach to Development Planning'. Seven of us would later receive the Nobel prize. The ultimate aim of the colloquium was not like today's environmental policies but development plans of countries like Egypt or India. But the discussion of principles concerned like now normative questions about a long-term future. Only the context was different. The issue was how to best schedule the investment drive to impose on people, knowing that it would compete with the great immediate needs of these people.

In order to define choice principles to be applied, we could hardly expect help from philosophers. It belonged to economists themselves to build their methodology. We indeed discovered then this reality that, in order to reason correctly about choice principles, you had to confront them with some representation of the context in which they would be applied. The representation had to be simple but somehow similar to the real context. The need to refer to a so stylized context is so true that it is now acknowledged by various philosophers like John Rawls who, more recently, aimed at elaborating the theory of justice.[1]

In this introductory exercise I shall refer to two distinct stylized contexts, the first evocative of one of the main problems in management of the environment, the second representative of what we were discussing in 1963. In the two cases, human persons, all assumed to be identical, belong each to one generation and successive generations are assumed not to overlap, each living just one period.

3. *Sharing Non-Renewable Natural Resources*

Attention is now limited to a case in which generations for their living need only to draw from a non-renewable resource. The hypothesis is made

[1] Note that in his famous 1971 book, *A Theory of Justice* (Harvard University Press), Rawls refers to the economic literature, especially to Pareto, Koopmans and Sen, when he sets out the 'principle of efficiency' and the 'difference principle', both belonging to the very core of his theory.

that what is consumed of this resource by a person can no longer serve to anything and that there is no other form of consumption. Moreover, the total available quantity of the resource is assumed known. Let us first assume also a finite number of generations. I need not insist on the unrealism of all the assumptions just listed. However, one element of realism remains in the stylized context so defined, namely the problem still stands to decide how to share the quantity of the resource between generations and between persons within generations.

The problem is now so simple that any reader knows the answer: justice requires an egalitarian distribution of the total quantity between all present and future persons, at least if they can survive with the quantity so allocated to them. Notice, however, that I wrote egalitarian distribution between persons, not between generations which may have more or less numerous populations. This is obvious to the reader, I suppose. But there was discussion on this point among economists, as is reported by Dasgupta. Indeed, applied to our stylized context, equal distribution between persons is chosen with his formula (5) with $\beta=1$ but equal distribution between generations with formula (4), which was presented here in 1963 by Koopmans (he obviously paid no serious attention to the fact that the assumption of equal number of persons in all generations was embodied in his axioms). How can it be that as shrewd a theorist as Koopmans had not realized that formula (5) had to be given? Simply because his intuition misled him: he did not think about an appropriate stylized context.

Applied to non-renewable mineral or oil resources in the ground, the hypothesis of *known* total quantities (that will ever be accessible to humanity) has to be dismissed as too unrealistic. In fact, estimates given in the past of such quantities turned out to be systematically too low. But it is unlikely that this will remain true for ever because the quantities in question are certainly finite. Without entering in the study of consequences to be drawn from such past underestimations, I may briefly explain one conclusion drawn from the approach usually applied by economists when they embody in their analysis uncertainty in our knowledge of the context. In this literary introduction I may feel less constrained than Partha who understandably assumes, for simplicity, a known world.

With respect to the stylized context used here, the change would be to introduce a probability law of the total quantity to be shared, a law that the central authority, the distributor say, would use when deciding about the share to be allocated to the present generation and to be equally dis-

tributed between persons of that generation. For simplicity in my presentation of this problem of programming under uncertainty I further assume: (i) there is a single person in each generation; (ii) the probability law is fully characterized by its mean and variance; (iii) the distributor knows how the utility attached by each present or future person to the share allocated to her or him would increase with the amount of the share; (iv) the utility in question would moreover increase less and less if the amount of the share would increase more and more. Then it can easily be proved that the share allocated to the first person would decrease as uncertainty would increase, more precisely as the variance of the probability law would increase, the mean remaining unchanged. In other words, increased uncertainty requires the distributor to be more prudent in allocating shares to members of the present generation. Such is the form of the precaution principle.

4. *An Undefinite Future*

Turning now to a different question, I must draw attention to the fact that the formulas written by Dasgupta assume an infinite number of generations. This is explained in his section 1 about the Ramsey formulation, in particular in his long footnote 1. In a few words: we well know that our world will cease existing at some future date; but this date is so indeterminate for us that it is much less irrealistic to assume in our reflections an undefinite future than any known terminal date, as was assumed in the foregoing section.

But this simple remark is devastating with respect to the egalitarian solution given above as applying to our first stylized context. With an infinite number of persons and a finite quantity of the resource to be shared, the egalitarian solution is absurd: for ever the share allocated to each 'living' person will be nil. In order to avoid this paradox while maintaining solidarity with future generations, a natural solution is to discount future utilities attached to the allocations of the resource, for instance to use formula (5) with a discount factor β smaller than one.

Partha explains that a similar paradox would occur in other contexts, covering in particular my second stylized context. He then points to the resulting ethical tension, which forces us to give less weight to generations remote in the future than to present generations. Once this is admitted, we may as well endorse Koopmans's logic, properly modified so as to lead to formula (5) rather than (3).

5. *Promoting Intergenerational Solidarity*

Formula (5) must be read as specifying that the central authority has to: (i) choose a function $U(c)$ caracterizing the utility derived by any person from an amount of consumption c, (ii) choose a discount factor β smaller than 1 to the detriment of the second generation, (iii) then select for implementation the transgenerational profile of individual amounts of consumption which maximizes V, given what is feasible in the relevant context.

Notice first that, while β has to be smaller than 1, it may be very close to 1. All depends on the force of the concern for future generations. With my first stylized context, the higher will be β the less will the distributor draw from the reserve of the natural resource to the benefit of the present generation.

Secondly, notice that, if the utility U was chosen proportional to c, the whole reserve would be allocated to the present generation and nothing would be left. But the distributor, like everybody else, is very likely to think that the utility of an additional euro is much larger for someone living with one euro per day than for someone living with ten euros per day. The function $U(c)$ must reflect this assessment, which rules out proportionality between U and c. The perceived utility of the additional euro, called the marginal utility in mathematical language, will have to be a decreasing function of c. The larger the rate of decrease the more will the distributor exhibit concern for future generations.

Hence, there are two ways to promote equity between generations: either to choose a discount factor β closer to 1, or to choose a function $U(c)$ such that the marginal utility decreases faster. One way or the other will lead to a smaller withdrawal from the reserve by the present generation.

6. *Marginal Rates of Substitution*

At this point in the context studied here so far, we understand the terms in which 'the problem to strike a balance between the well-being of present and future generations' is posed (see first two lines of section 1 in Dasgupta's paper). We must now go a little deeper into this problem because doing so will help us to perceive how, more generally, all dynamic programming questions raised by the economics of the environment are approached, where the balance between the interests of present and future generations is always at stake.

Going deeper requires the introduction of a few useful mathematical concepts and even presentation of one mathematical result, but technical

aspects will be avoided as much as possible. The reader understands this is not the place for a display of mathematical rigour. Let us begin with heuristic considerations.

In all cases one has to confront what is desirable with what is feasible. Striking a balance means that one has to find, in the set of feasibilities, the point beyond which the interest of the present generation would be favoured or sacrificed more than intergenerational justice requires. Well-being of the present generation has to stand just at the margin between excessive greed and excessive austerity. We then understand why appropriate mathematical concepts are denoted as 'marginal': they have to permit assessments at the margin. The main focus of attention then concerns substitutions of a little more to the next generation for a little less to the present generation. One has to make assessments on the one hand for what would remain feasible and on the other hand for what would remain equitable. Hence a concept of marginal rate of substitution in feasibilities and a concept of marginal rate of substitution in equitabilities, both between the consumptions of two persons belonging respectively to the present and the next generation (for the substitutions here contemplated which are moreover assumed to occur without any change in the consumptions of other persons). There is an intuitively natural theorem: when the correct balance is struck, the first of these two marginal rates is equal to the second.

Application of this theorem is fairly easy with the stylized context of the sharing problem as I defined it and extended it to an infinite number of generations. Indeed, the marginal rate of feasibilities is equal to 1: giving one more unit of the resource to a person of the next generation requires that the person designated in the present generation receives one unit less, when consumptions of all other persons remain unchanged. Let me now sketch the consequence of the theorem for this case.

Given the meaning of intergenerational well-being, designated by V in Partha's paper, an equitable substitution has to leave the value of V unchanged. Let c_1 and c_2 be respectively the consumptions of the two persons concerned. Consider two small changes in these consumptions $-dc_1$ and $+dc_2$. The utilities drawn of the consumptions will change by the amounts $-U'(c_1)dc_1$ and $+U'(c_2)dc_2$, where U' is the derivative function of U. In the spirit[2] of for-

[2] Formula (5) assumes that all persons of the same generation receive the same consumption. Here only one person of generation 1 and one person of generation 2 experience a change in their consumption.

mula (5) the value of the indicator V will remain unchanged if: $-U'(c_1)dc_1+\beta U'(c_2)dc_2=0$. The marginal rate of substitution in equitabilities dc_1/dc_2 is then equal to $\beta U'(c_2)/U'(c_1)$. Given the theorem, a program which strikes the balance must be such that this ratio be equal to 1. Since β is smaller than 1, the value $U'(c_2)$ must be larger than $U'(c_1)$. But we have seen at the end of our foregoing section that the marginal utility $U'(c)$ decreases as a function of c. So $U'(c_2)$ larger than $U'(c_1)$ means that c_2 is smaller than c_1.

As a qualitative result it is really not surprising: the conclusion that c_1 should decrease with time in the future is a direct effect of discounting the future. But such equations as $U'(c_1)=\beta U'(c_2)$, written for all conceivable substitutions, together with the resource constraint, lead to a full quantitative determination of the intended dynamic program. Similarly in different contexts a set of equations is derived from the theorem which, together with feasibility constraints, solves the problem.

7. *Striking a Balance Between Investment and Consumption*

My second example of a stylized context is meant to provide a simple image of what was discussed here in 1963 and has also been studied most often in economic theory since then. Development plans, as contemplated at the time, aimed at coping with the capital shortage which was maintaining poor countries in underdevelopment. To pull countries out one had to irrigate lands, produce fertilizers, increase transport equipment, and so on. In short, investments were required, hence savings to be withdrawn from what could also have been used for immediate consumption. In return, levels of consumption would later be raised. The problem was to know how to best plan not only the initial saving but also the future joint growth of investment and consumption.

The context had a few essential features. Production would be all the higher as the volume of capital would be larger, and this according to what productive techniques would permit. Production would be allocated in part to investment, the surplus going to consumption. Investment would imply an increase in the volume of capital. For our reflection is now considering aggregates suffices: hence four amounts in each period (production, capital, investment and consumption) and three necessary relations repeatedly applying along the sequence of periods. The first relation stipulated that the capital of the next period would be the sum of capital available in the current period and investment. The second relation gave production as a function of capital, the 'production function'. The third relation defined con-

sumption as the difference between production and investment. The problem was to maximize an objective function such as *V* defined by Partha in his equation (5). The solution of the problem gave in particular the 'optimal' series of consumption levels period after period.

Of that solution I shall quote here just one element, namely that the marginal rate of substitution in feasibilities between the consumption of a period and the consumption of the previous period directly depends on the marginal productivity of capital in the later period of the two. But this productivity, hence also the marginal rate of substitution, varies from one period to another: it is normally all the higher as the period begins with a lower capital. For countries initially suffering from capital shortage the usual conclusion states that, even with an unchanged technology not to speak of technical progress, the optimal program leads to an increasing time series of consumption levels. This is a just reward for the saving effort imposed since the beginning.

8. *Substitution of Produced Capital to Non-Renewable Natural Resources*

In the second stylized context no other natural resource than labour is present. But there is no difficulty in principle to combine the two stylized contexts, so as to account for the simultaneous existence of both produced capital and non-renewable natural resources. To refer to such a combination is even appropriate within any discussion about the attention to be given to the physical environment in a long-term strategy of intergenerational solidarity. Indeed, environmentalists closely study the feasibilities of developing and using techniques thanks to which capital produced from labour would be substituted, at least in part, to scarce natural resources.

Such is the purpose of many research projects which collect factual and scientific information about the phenomena involved. The ultimate goal of such research is to better gauge feasibilities and to discover new ways to restrict the use of non-renewable resources. The last Development Report of the World Bank[3] is paying much attention to the issue. If our Academy further extends its investigations about environmental policies, we also should pay attention to this research.

[3] *Sustainable development in a dynamic world – Transforming institutions, growth and quality of life*, World Bank, 2003.

9. *What Should We Mean by Consumption?*

In his section 1 Dasgupta refers to 'some generalized consumption' as the determinant of each generation's well-being. Such a consumption is meant to include 'food, clothing, shelter, health care, serenity, leisure activities, legal aid and various types of public goods (including civil and political liberties and direct amenities from the natural environment)'. In other writings Partha distinguishes 'welfare' from 'well-being', which differ because well-being ought to be measured from generalized consumption whereas welfare is usually evaluated from consumption, as may be found for instance in national accounts.

With respect to the earlier literature and to the object of our discussions in 1963, this is a new concept. Although I agree that the distinction makes sense, I want to also voice a warning. Proposing to replace 'welfare economics' by 'well-being economics' is a clear way of recognizing the validity of the criticism which long since blames economists for their too narrow conception of welfare. To this criticism we have been used to reply: 'Yes, economic analysis is not sufficient for dealing with some realities. For instance, it belongs to political analysis to speak about civil and political liberties, to evaluate and to explain them'. We often add, by the way, that those liberties do not appear to actually be in contradiction with economic welfare, as we measure it. It seems that such common type of reply was not enough and that critics would have liked to see all non-strictly-economic features being embodied in our analyses. With his comprehensive concept of well-being Dasgupta shows that we have no objection in principle to doing so.

But replacing 'welfare economics' by 'well-being economics' ought not to mean just a change in our vocabulary. It will be understood by some readers as a commitment. Are we able to fulfil the expectations so raised? Intuition leads me to have doubts in this respect. My job as a statistician is clearly part of the story: in order to merge with economic aggregates such as household consumption the now available indices of civil and political liberties, where could I find objectively justifiable weights to be respectively given both? The difficulty of the answer is revealing the still more challenging questions we would have to face in applied comparative analyses involving the concept of generalized consumption. Moreover I have serious doubts about attempts made so far by economists for significantly extending the domain of my discipline. For instance the so-called 'new political economy' brings very little in comparison with the previous state of affairs, according to which we added to the presentation of results reached by our economic analyses some common sense comments about possible interference of political factors.