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Managing natural resources without forgetting future generations: Two alternatives to discounting

Our current choices regarding the fight against deforestation and climatic disorder, against the overexploitation of natural resources or the erosion of ecologic heritage, have effects which will last long after we disappear. Must we make immediate and major sacrifices for the well-being of our descendants? Speaking only about developed countries, they will anyway be better off than we are if the trend in growth observed for the last two centuries continues. Unless, as scientists and GIEC Experts who work on biodiversity and ecosystem services fear, we are approaching the natural limits which commit here and now our responsibility towards future generations. In a context where current choices have uneven distributed effects in time, how do we arbitrate between the present and future, between the interests of the various generations?

One way of considering the problem is to incorporate some normative requirements into a criterion of inter-temporal social choice, and estimate the legitimacy of alternative futures according to their classification by this criterion. This approach results in a general message as important as it is frustrating: looking for the trajectories of management which avoid waste cannot usually be achieved without favouring certain generations. Therefore, the concern for our descendants can be summed up to one question: what are the desirable compromises between efficiency and impartiality? Discounting the utilities of every generation before adding them together is a possible answer. But such a criterion, for a long time applied by default, presents an all the more contestable discrimination against future generations, all the more so as alternatives exist. This note briefly presents the works of the scientists of the SAE2 department on two alternatives to discounting. Chichilnisky's criterion and the mixed Bentham-Rawls (MBR) criterion are two possible answers to the efficiency-impartiality dilemma.

Criterion of inter-temporal choice and dilemma between impartiality and efficiency

In its simplest and most abstract form, the literature on inter-temporal social choice considers fixed-size generations which follow one another to infinity. They only differ by their position on the temporal axis and possibly, by their allocations in natural resources. Generation t, ($t = 0, 1, \infty$), consumes resource, let us say c_t, and gains satisfaction assessed by a so-called utility function $u_t = u(c_t)$, supposed to be increasing with consumption.

The scenarios of exploitation of the resources amount to infinite chronicles of utilities u_0, $u_1,\ldots,u_t,\ldots$

In the search for a criterion of inter-temporal social choice which will allow their ranking, we try to respect both the following axioms:

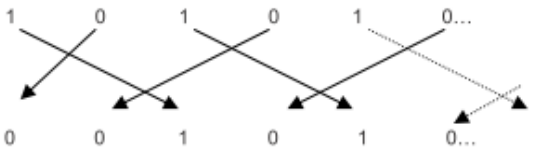
1. Axiom of *efficiency* or strong Pareto (SP): a criterion verifies SP when a chronicle of utilities is declared better than the other if at

least one generation is better off and no generation is worse off.

2. Axiom of *strong anonymity* (SA): a criterion verifies SA when two chronicles are declared equally good if one is obtained from the other one by means of permutations of generations on the time axis. This kind of procedural impartiality forbids treating generations differently only because of their temporal position.

Since recently, we have known that imposing at the same time SP, SA and other reasonable requirements such as completeness and representability (a grading criterion is said to be complete when it allows an organization of all the options into a hierarchy; it is representable when it can be put into a bijective relation with a function defined on the options, and the numerical values of which reproduce the classification), ends up in an impossibility (Zamé, 2007; Lauwers, 2010).

As an illustration, let us consider the following chronicle of utilities: (1,0,1,0,1,…). Let us move generation 2 into first position, then all the other even generations two periods earlier and all the odd generations two periods later, in the following way:



A second chronicle (0,0,1,0,1,…) is obtained that only differs from the previous one by its first value. By virtue of the axiom SA, the second chronicle is socially equivalent to the first one because it is obtained by means of permutations between generations. But the respect of SP should declare it weaker, since in the first chronicle, the first generation is strictly favoured whereas all the other generations are just as well off.

This dilemma illustrates the arbitration between impartiality and efficiency which confronts every construction of an explicit criterion of inter-temporal choice. In what follows, we present two examples of criteria that make concessions on impartiality and discuss their respective properties.

A "satisfactory" use of Chichilnisky's criterion

Chichilnisky's (1996) criterion, denoted J^C is defined as follows:

$$J^C = \theta \sum_{t=0}^{\infty} (1+\delta)^{-t} * u_t + (1-\theta) \lim_{t\to\infty} u_t, \quad \delta, \theta \in]0,1[. \quad (1)$$

Where θ is a weighting parameter and δ represents a discounting rate. It is written as the weighted mean of two other criteria of inter-temporal choices.

The first one, called the Discounted Utilitarian criterion (DU), follows the familiar and widely criticized logic which consists in adding together the discounted satisfactions. Clearly, criterion DU does not respect procedural impartiality SA. Discounting means granting lesser importance to a generation the further away it is in time. More precisely, the utility of the current generation is assumed to be affected by a unit weight, the utility of the second generation is affected by a weight $(1+\delta)^{-1}$, the weight of the utility of the third generation is $(1+\delta)^{-2}$, and so on. The rate δ assesses the preference for the present. It indicates the equivalence between a unit of satisfaction of the current generation and $(1+\delta)$ units of satisfaction for the second generation, or $(1+\delta)^2$ units of satisfaction for the third generation, and so on. If the discounting rate δ is null, a strictly positive discounting rate means a preference for the present which is all the stronger the higher parameter δ is. Whatever the value of the latter, the future is always reduced more the further away it is. With a linear utility function and a 10% discounted utility, the entire current GDP of France would not be valued any higher than the price of a luxury house today, if it were only consumed in two hundred years. Since discounting makes the criterion rather insensitive to the fate of further generations, we speak of *dictatorship of the present.* For an exhaustible resource, if utility only depends on its consumption, the best rule of extraction according to criterion SA is to exhaust the stock in the long term. This may go against the "conservationist" requirement that many people associate with the notion of sustainability.

The famous Stern report (2007) on the costs of climate change revived the debate on the value to be given to parameter δ. The experts were divided in their views on the inequitable nature of discounting. When generations grow richer, discounting gives relative weights which correct

this trend towards inequality. The argument is no more legitimate if there is a trend towards poorness or stagnation.

The second term in J^C is sometimes called the Green Golden Rule (Chichilnisky, Heal and Beltratti, 1995). It looks for trajectories of exploitation which result in the highest level of stationary utility in the long term. By definition, the Green Golden Rule avoids the dictatorship of the present. But in order to maximize the utility of the farthest-away generations, it recommends null consumption of the exhaustible resources and later on, maintenance of stock at initial levels. While the discounted utilitarian criterion implies a dictatorship of the present, the criterion of the Green Golden Rule imposes the *dictatorship of the future*.

If we take as a criterion the weighted mean of a dictatorship of the present (criterion DU) and a dictatorship of the future (the Green Golden Rule), criterion J^C does not suffer from any of these two defects. If we require three other properties - continuity, linearity and efficiency - it is even the only criterion which avoids both dictatorships. Applied to the management of an exhaustible resource, Chichilnisky's criterion considers as optimal a trajectory which, in the long term, keeps the stock at a certain bottom level, the latter being higher than the minimal stock prescribed by criterion DU and lower than the stock that it is advisable to maintain according to the Green Golden Rule.
However, Chichilnisky's criterion raises a problem. When it is used for the management of a renewable resource, there is no trajectory to maximize it. This difficulty has given rise to some technical literature which suggests solutions and discusses their merits.

Figuières and Tidball (2010) suggest a "satisfactory" use of Chichilnisky's criterion: this involves maximizing J^C on a restricted set of trajectories of exploitation. This set contains all the trajectories which are obtained as combinations of the chronicle of optimal exploitation for criterion DU and the optimal chronicle for the Golden Rule.

By doing this, we can demonstrate the existence of a solution which possesses interesting ethical properties. Under certain conditions this solution produces no loss of efficiency, leads to a lesser exploitation of the resource than criterion DU does and redistributes well-being in favour of the intermediate generations.

It is as if the decisions maximized a criterion DU built with a fictitious discounting rate weaker than the real rate. Furthermore, the optimal trajectory in the restricted set of controls is sensitive to parameter θ: the more criterion J^C expresses an interest in future generations - that is to say the bigger θ - the weaker the pressure on the natural resource. In other words, this "satisfactory" approach makes operational the ethical choice between the present and future which preside over the construction of J^C. In the long term, a "satisfactory" trajectory reaches a stock of resource which is all the higher the greater the importance granted to the future (parameter θ). The chronicles of consumption which reach this stock are monotonously increasing (respectively decreasing) when the initial stock is lower (respectively above) than the one which must be reached in the long term.

Properties of the mixed Bentham-Rawls (MBR) criterion and the Rawlsian principle of just savings

The MBR criterion is another mixed construction:

$$J^{mbr} = \theta \sum_{t=0}^{\infty} (1+\delta)^{-t} * u_t + (1-\theta) \min(u_0, u_1, ..., \infty), \quad \delta, \theta \in]0,1[. \quad (2)$$

It proposes a weighted mean of the utilitarian discounted criterion DU and of the *Maximin* criterion. The latter, sometimes improperly called *Rawlsian criterion*, declares as optimal the trajectories for which the fate of the most discriminated generations is the best. Using such a criterion in the simple model of growth with an exhaustible resource leads to null growth. As long as the growth is positive, it is indeed always possible to increase the utility of the least favoured generation, in this particular case the first one, by reducing its rate of savings to raise its consumption up to the level of the other generations. The same logic prevails for the following generation and so on, until all the generations consume the same thing. The optimum is only reached when growth is null. With such a criterion, a poor economy remains indefinitely poor, even when the initial conditions would allow its growth in time. This criterion is again similar to a dictatorship, as it were, the dictatorship of the most discriminated generation which, however, with finite savings, even low

ones, would produce an excess of consumption for the infinity of its descendants.

We reach mixed criterion J^{mbr} when we discard the dictatorship of the most discriminated generations, as well as the dictatorships of the present and future, without, however, requiring linearity as Chichilnisky does (Alvarez-Cuadrado and Long, 2009). Finding the best trajectory for criterion J^{mbr} is the same as maximizing criterion DU under a new constraint which forces us to take into account the fate of the worst-off generations.

The other properties of this mixed Bentham-Rawls criterion, in particular the shape of the optimal trajectories, are set in Alvarez-Cuadrado and Long (2009) and Figuières, Long and Tidball (2010). For a renewable resource, in an "initially rich" economy, that is with an initial stock above the long-term stock under criterion DU, the consumption of the resource by the first generation may be high before stabilizing at a lower level.

But if, on the contrary, the economy is initially poor, the rule of exploitation is in accordance with the *just savings* Rawlsian principle which defends "a two-step" logic. During a first phase, every generation has to save so as to transfer more to the following generation than it inherited from the previous one until, in a second phase, "once the right institutions are firmly organized and all the basic liberties are effectively implemented, the required net accumulation falls to zero" (Rawls, 1971). However, the position of Rawls is differentiated from the MBR criterion in the sense that it does not defend the metrics of the utility as the value on which the ethical reflection should be based.

Therefore, the idea is that of a phase of accumulation during which savings are required if the initial conditions are bad, followed by a cruising phase where the savings are possibly permitted, but dissaving forbidden. Additionally, if the principle of equality which prevails in the second phase is reminiscent of the Maximin logic, it is subordinated to the necessity of a minimal take-off in comparison with the condition of "under-development". This logic does not require exaggerated sacrifices from the intermediate generations in comparison with the first ones.

What consequences for interest rates?

By way of conclusion, let us discuss the practical impact of these conceptual works.

Discounting, or more generally, the distribution of weights to the generations that we have so far considered, concerns utilities. How is it translated in the material world, for example to express the relationship between a unit of consumption for a generation to come and a unit of consumption today?

As a rule, with any trajectory of exploitation which will have been considered desirable with regard to a criterion like J^c or J^{mbr}, it is possible to associate a chronicle of discounting rate of consumption which would give it substance. The switch from the discounting rate of utility to the discounting rate for consumption is done according to the Keynes-Ramsey formula (see frame).

The Keynes-Ramsey formula

$$r_t = \delta + g_t * \mu_t. \qquad (3)$$

This expression shows that discounting rate r_t of consumption of generation t is equal to the amount of the discounting rate of utility δ and of the product of the growth rate of consumption, g_t, by the elasticity of marginal utility μ_t. The second term shows a form of aversion to inequality: the discounting of the consumption is all the stronger (weak) as its growth is positive (negative).

One arrives at this Keynes-Ramsey relation when, for example, one looks for what condition a decline in consumption ΔC_t at some time t could be exchanged against an increase in consumption ΔC_{t+1} at time t+1. Both these variations are equivalent when their ratio is 1+ r_t leaves unchanged the value of criterion DU. Formally, this question finds its answer in an expression

which connects the ratio

$$1 + r_t = -\frac{\Delta C_{t+1}}{\Delta C_t}$$

with fundamentals of the economy, the discounting rate of utility δ and the elasticity of marginal utility μ_t. The Keynes-Ramsey rule is a rough estimate of this expression. Under certain conditions, this rule also applies for the "satisfactory" solution of Chichilnisky's solution, as for the solution of the MBR criterion.

In practice, for numerous investments, it is the yield of private capital which indicates if and to what extent it is interesting to save for bigger future consumption. Sometimes it may also be the result of experts' calculation, as is the case in France for the projects on which the Strategic Analysis Centre has to decide. Could these prices, formed on markets or calculated, reproduce those theoretical ones, stemmed from equation (3)?

As regards prices on markets, it is unlikely. To begin with, for Chichilnisky's criterion as for the MBR criterion, we can observe that the growth rate of consumption may be negative before becoming null if the initial conditions of the economy are too favourable, that is to say higher than the long-term stock under criterion DU. In such cases, the interest rates in consumption are lower than the discounting rate of the utility, and they can even be temporarily negative! We rarely observe market rates which indicate that a euro of consumption of tomorrow is worth more than a euro of consumption today. Even outside the markets, the works of experts worried about intergenerational ethics but extrapolating positive growth in consumption systematically recommend positive rates. The famous Stern report on climate change gives a 1.4 % rate a year, which is already significantly weaker than the proposals of other reference works, where the rates for the choices of public investments can evolve between 4% for a horizon of 30 years and 2% beyond 60 years.

But in a less trivial way, a market synthesizes information and aggregates the participants' preferences which have a physical and legal existence. However, future generations, necessarily absent from these markets where the decisions which concern them are taken, cannot have their concerns put forward. The interest rates which result are inevitably biased in favour of the current generation. At best, after many heroic hypotheses on the completeness and perfection of markets, we can expect that they replicate the chronicle of interest rates associated with the trajectory DU, but doubtless not those of the trajectories for J^c or J^{mbr}, for which the rates are likely to be lower.

There are undoubtedly alternatives to discounting, with ethical foundations which express a real concern for future generations. But our societies are not really organized, both in the economic and legal domain, to follow the requirements of equity between generations incorporated into criteria like J^c or J^{mbr}. To give them substance, it is tempting to suggest a paternalist posture or institutional innovations which would allow the creation of markets where the "price of time" is set for periods going beyond a few decades and on which the interest of the not yet-born generations can be demonstrated.

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For further information

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