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Necessity of special discounting for nature resources, production and services to assess the effectiveness of investments

The purpose of the paper is to demonstrate the necessity of special natural discount rates during conservation activities efficiency assessment. The social rate of discounting originated by D. Pearce is often used now. However much of values of ecosystem origin differ in such aspects as absence of high-grade anthropogenic substitutes and conservative character of natural "technologies", and consequently, simple, not extended reproduction. As a result there exists the necessity of special discounting rate for non-replaceable production and services having restrictions in capability of their reprocessing and consumption, which follows from the analysis of consumer choice trajectory in the course of budget growth over a level at which the maximum of consumption of the limited good is reached. The paper estimates the reduction value for discounting rates in the special case of individual utility functions of Cobb-Douglas type and – for collective consumption of renewable natural resources, restricted in reproducing possibility – equal parts resource sharing among consuming community members. The idea of special discount rates for the production and non-material services of ecosystems is useful both for economic efficiency assessment of nature conservation activities and for calculation of compensations from the activities worsening environment quality.

Keywords: discounting, natural discount rate, investments, ecosystem production, ecosystem services, effective strength of environmental activity

Introduction. Often applied practice demands either aprioristic comparison of various variants of a planned direction of investments, or a posteriori estimation of efficiency of someone or other set of actions in comparison with an imagined situation of their absence.

Let's describe 4 most typical examples.

Variant NF (Nature in the Future). It is required to compare, for example, some variants of national park organization or of realization of tree-planting works. It is implied that any of these variants increases the utility, received from functioning of conserved, improved, restored or originated ecosystems, but, probably, leads to losses from the missed opportunities of alternative use of the occupied lands or of the resources located on them.

Variant AF (Anthropogenic in the Future). The investment project of private or public applicability is calculated, which as a by-effect leads to the reduction of a stream of production and services of destroyed or modified ecosystem or to deterioration of environment characteristics. It is required to estimate practicability of the project from complex ecological economic point of view: whether planned new values of anthropogenic origin will outweigh ecological losses.

Both of described variants NF and AF plainly demand for putting to the current time the estimations of various variants of planned conditions of natural stocks and streams of ecosystem production and services. Thus a hectare of a forest today and a hectare of the same

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forest planned to occurrence in 70 years apparently have for a human different current, normalized to today's perception, value. So there arises the problem of correct discounting.

Let's consider 2 variants leftover.

Variant NP (Nature from the Past) arises, when nature protection or environmental engineering actions have been carried out, which has led to increase of steady streams of resources and services of ecosystems origin useful for human beings or to the occurrence of a predictable trend of increase of stocks of such resources in comparison with the current condition or with the outlined tendency in the lack of such actions.

Variant AP (Anthropogenic externalities from the Past) arises, when as a result of realization of the investment project or fulfillment of current economic activity there were by-effects (especially – unexpected or earlier not considered), that have led to decrease in stocks of resources or steady streams of production and services of ecosystem origin or to occurrence of a predicted trend of such resources or flows reduction. In this case a question gets up on the sizes of indemnifications from originators of such changes.

Variants NP and AP also lead to necessity to select the rate of discounting for the goods of ecosystem origin (or a set of various rates for the natural goods of different types) on which the activity of two types mentioned has affected. (Let's notice, that when actions of types NP or AP lead to a simple lump-sum change of material stocks of ecosystem origin resources, the problem of the correct rate of discounting choice does not rise.)

Theoretical analysis of the problem: starting positions. Problems of given paper do not include research of the tendency of the rate of social discounting to change (namely – to abate) with increase in horizon of planning or, may be, simply with a course of normal economic development. The good review of such researches and approaches to their realization give, for example, papers of Pearce, Groom, Hepburn, and Koundouri (2003) and Groom, Hepburn, Koundouri, and Pearce (2005).

The task of our contribution is to show, that discounting of non-replaceable production and services of ecosystem origin should have other character, than even that for socially consumed goods of anthropogenic origin, and also to try initial ways to the estimation of comparators between various sorts of discounting rates.

Probably, its materials will seem to a reader not worked up to the end and having debatable character. However we hope that it will manage to highlight a number of specific features of ecosystem goods to which insufficient attention in former development under the theory of discounting was paid, and also to plan some approaches to the decision of the problem put forward, taking given specificity into account.

Now most often is used the so-called social rate of discounting originated by D. Pearce. This approach considers the goods having an ecosystem origin having social importance of the same nature as, for example, free-for-all asphalted parking for personal motor transport. It is considered, that the rate of social discounting estimates pure intertemporal preferences of a society unlike commercial rates estimating possible speed of the capital gain at its alternative investment.

However, unlike parking asphalt, many of ecosystem goods differ in such aspects as, *first*, absence of high-grade substitutes among made by anthropogenic technologies and, *secondly*, conservative character of natural "technologies" and, as consequence, simple, instead of the expanded reproducing of these goods.

It appears that at an estimation of any of the types mentioned in the introduction, touching the goods of ecosystem origin, the establishment of uniform, let even varying from year to year, but general for all goods, expenses and benefits, low rate of discounting inevitably leads to losses in the nearby horizon of planning.

First, concerning a conventional good, for which threat of neither loss of sustainability nor impossibility of replacement exists, it is natural to assume, that a person, most likely, will prefer to have some its quantity already today, instead of once in uncertain future.

Secondly, when the rate of discounting is made compulsorily low without distinction concerning type of the discounted goods, the opportunity of reinvestment of financial assets which can be received from projects with fast feedback is underestimated.

Necessity of decrease in the rate of discounting for the goods limited in capability of reproducing. Let's consider a typical, well-known from many of basic level textbooks on economics, situation of the individual choice between consumption and non-consumption (spending the remained part of expenditure budget for other goods) of some fixed good, presented on figure 1.

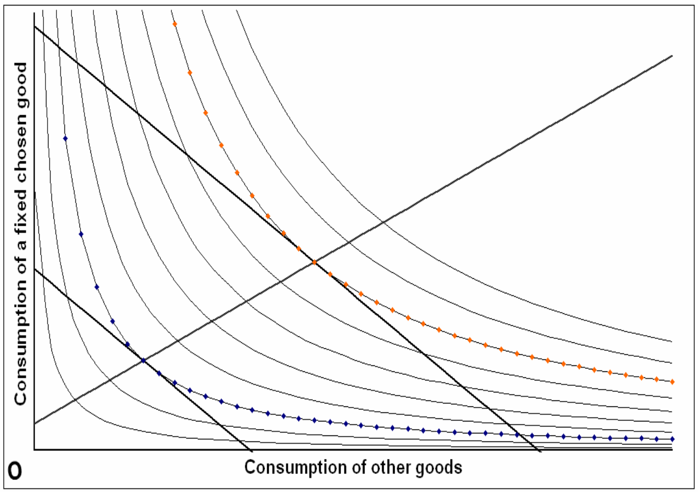

Fig. 1. Indifference curves map, budgetary restrictions, and consumer choice trajectory concerning consumption of the fixed chosen good in comparison with expenses on consumption of others

In this figure each curve sets some fixed level of total satisfaction from simultaneous consumption of all goods. Therewith one good is opposed to all other consumed by an individual, and their consumption is estimated by the sum of money spent on them. Any of points of any fixed curve on the diagram is of equal preference for the individual, and a real choice is determined by contemporaneous aspiration of expenses minimization. We consider, that money act as a uniform measuring instrument for expenses of various sort. Expenses can be financial, expenses of time, physical strengths, "moral", and, probably, others. The choice of the individual is carried out between consumption of the fixed chosen good during any time interval, for example, month, and consumption level of the other goods. As assumed simplifications it is considered, that total expenses on maintenance of consumption of the considered good are directly proportional to the quantity of consumed units, and consumption of the other goods is measured directly by money's worth of the expenses connected with it. Descending inclined straight lines display budgetary restrictions at various levels of a consumption budget. The osculation points of these straight lines to curves of maximally accessible utility levels represent real consumer selections at various levels of the budget. The consumer choice trajectory is presented on our diagram by an ascending inclined straight line (generally the trajectory of a choice can be a line of more complex configuration) connecting these points. The slope of an indifference curve in its arbitrary point characterizes the value of additional unit of the fixed good. Namely – the steeper the backslope of a curve, the more valuable to the individual is consumption of an additional unit of other goods in comparison with consumption of a unit of the fixed chosen good. The backslope of an indifference curve shows marginal relative value of the good represented on the horizontal axis.

Let us concretize now, that the fixed chosen good is trips on the nature, and let us notice, that the maximal number of trips on the nature during a month has natural restriction, for example, by number of days in a month or by number of week-ends. The consumer choice trajectory is now transformed towards a visible presented on figure 2.

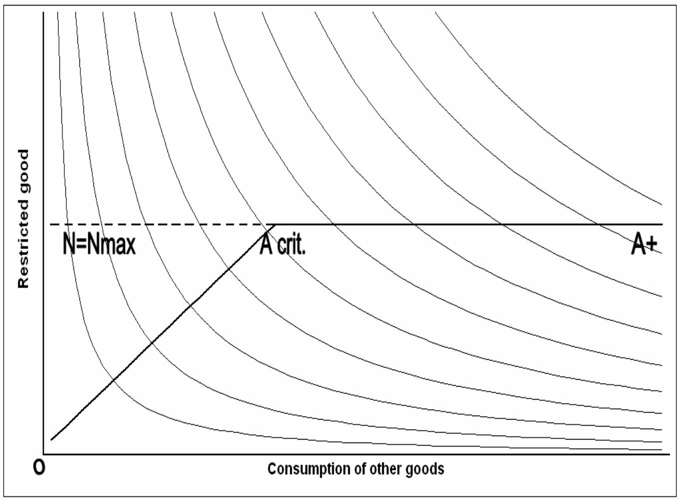

Fig. 2. Indifference curves map and consumer choice trajectory at existence of consumption restrictions for a fixed chosen good (case of homothetic utility function)

While the consumer budget not reach critical value at which he or she, carrying out distribution of expenditures and maximizing the general utility, reaches the greatest possible consumption of the restricted good, the point of the consumer choice moves along the segment OA_{crit} of choice trajectory. Therewith in a point of a choice, the relative value of the consumed goods is determined by the parity of the expenses connected with consumption of each good (in an ideal case of absence of time, "moral" and other transactional costs it is determined by the parity of their prices). Further, at excess of the budget critical level, the consumer choice trajectory is forced to go along horizontal half-line $A_{crit.}A_{+}$, and in a choice point the marginal relative value of restricted good against unlimited one, equal to the reciprocal of the crossed indifference curve obliquity tangent, starts to grow.

Appraisal of effect intensity: the single consumer case. *The case of restricted resource consumed individually.* In economic textbooks (see, for example, Nicholson (1995)) the representation of indifference curves through the assemblage of graphs of equi-potential values of Cobb-Douglas type utility function

$$U = K \cdot L^{\alpha} \cdot M^{\beta}, \quad (1)$$

is very popular as illustrative. Here K is non-dimensional constant factor; L is the consumption of one good, for example, quantity of trips on the nature; M is the consumption of other good, for our example it is the consumption of all other goods estimated by money's worth of expenses, associated with its realization; α and β are power indices greater of zero.

Assuming cost of a trip suburb equals p, and general budget spent for consumption equals B, we get an optimization problem:

$$\begin{aligned} & p \cdot L + M = B \\ & L \le L_{\max} \\ & L^{\alpha \cdot} \cdot M^{\beta} \to \max \end{aligned} \quad . \quad (2)$$

While the budget is not more than critical $B_{crit.} = \dfrac{p \cdot L_{\max} \cdot (\alpha + \beta)}{\alpha}$, then the decision of a problem will be $L_{opt.} = \dfrac{\alpha \cdot B}{(\alpha + \beta) \cdot p}$. Marginal value of an additional trip to the nature suburb in a point of an optimum now will be equal to p , i.e. costs of its realization. Let now $B > B_{crit}$.

Thereafter

$$L = L_{max}, \quad (3)$$

$$M = B - p \cdot L_{\max}, \quad (4)$$

$$V_{L/M} = \frac{\alpha}{\beta} \cdot M/L = \frac{\alpha \cdot (B - p \cdot L_{\max})}{\beta \cdot L_{\max}}. \quad (5)$$

If we observe that $B = B_{crit.} + \Delta B$, where ΔB is the budget excess above critical, we can transform formula (5) to

$$V_{L/M} = p + \frac{\alpha}{\beta} \cdot \frac{\Delta B}{L_{\max}}, \quad (6)$$

that showing evidently the dependence of limited good value growth from the size of excess over the critical budget: the increase of value is in direct proportion to the increase of the budget.

The case of common pool resources and growing number of members for an individual. Let us consider an elementary model of the operation of renewable common pool use (i.e. rival and non-excludable) resource having annual productivity of A units.

The use of annual resource harvest is shared among *N(t)* members of local community. Let the number *N(t)* grows eventually in a geometrical progression

$$N(t) = N_0 \cdot (1+\nu)^t. \tag{7}$$

The consumer budget of each community member also grows in a geometrical progression:

$$B(t) = B_0 \cdot (1+\gamma)^t. \tag{8}$$

It is supposed: a) that consumption of a common pool resource has already reached the stage of admissible maximum, and it is shared in equal parts among community members:

$$A_j(t) = A / N(t), \tag{9}$$

where j is the index of a community individual member; b) that general individual utility from the consumption of an investigated resource and the total consumption of all other goods is described for every community member by the same time-constant utility function of Cobb-Douglas type:

$$U_j = K \cdot L_j^{\alpha} \cdot M_j^{\beta}. \tag{10}$$

Then for the time moment t: $L_j(t) = A / N(t)$, $M_j(t) = B(t) - p_j(t) \cdot L_j(t)$,

$$V_L^j(t) = \frac{\alpha}{\beta} \cdot \frac{B_0 \cdot (1+\gamma)^t - p_j(t) \cdot L_j(t)}{L_j(t)} = \frac{\alpha}{\beta} \cdot \left(\frac{B_0 \cdot N_0 \cdot (1+\gamma)^t \cdot (1+\nu)^t}{A} - p_j(t)\right). \tag{11}$$

Here $p_j(t)$ is the j-th community member's size of expenses on withdrawal and consumption of the last common pool use resource unit, that is marginal value of the resource.

If the size of *p(t)* is or eventually becomes negligible in comparison with $\frac{B_0 \cdot N_0 \cdot (1+\gamma)^t \cdot (1+\nu)^t}{A}$, then the formula (5) can be transformed to the form of

$$V_L^j(t) \cong \frac{\alpha}{\beta} \cdot \frac{B_0 \cdot N_0}{A} \cdot (1+\gamma)^t \cdot (1+\nu)^t \tag{12}$$

and individual ratio to lower discounting factor for the resource marginal value will be $(1+\gamma)\cdot(1+\nu)$. So the corresponding discounting factor seems to be near $r-(\gamma+\nu)$, where r is the discounting rate for conventional goods in social-oriented projects.

Effect intensity for social community in whole. The case of common pool resource. Let us note that formulas (11) or (12), in assumption, used usually by default, of simple additivity of public utility function in reference to composing it individual utilities, give us also the appraisal of the effect for community in whole for the case when the marginal effect of the actions directed on improvement of resource functioning or on reduction of the tendency to its disruption is estimated for common pool type of resources, as the arising marginal effect is consumed competitively, i.e. only once: strictly by one of the community members or sharing by several members in some proportion.

The case of real public goods. Let now A to be a productivity of service, providing a real public good (i.e. non-rival and non-excludable).

Let once more the consumer budget of each community member also grows in a geometrical progression:

$$B(t) = B_0 \cdot (1+\gamma)^t . \tag{13}$$

It is supposed: a) that consumption of a real public good (something like visiting of picturesque places or consumption of protect ability from floods) has already reached the stage of admissible maximum (in other words: community members are rich enough to allow themselves some amount of it, but further rise of it is consumption is restricted by non-economic reasons), and all have it in full measure:

$$A_j(t) = A , \tag{14}$$

where j is the index of a community individual member; b) that general individual utility from the consumption of an investigated resource L and the total consumption of all other goods M is time-constant and is described for every community member by the same utility function of Cobb-Douglas type:

$$U_j = K \cdot L_j^{\alpha} \cdot M_j^{\beta} .$$

Then for the time moment t: $L_j(t) = A$, $M_j(t) = B(t) - p_j(t)\cdot A$, $V_L^j(t) = \frac{\alpha}{\beta}\cdot\frac{B_0\cdot(1+\gamma)^t - p_j(t)\cdot A}{A} = \frac{\alpha}{\beta}\cdot(\frac{B_0\cdot(1+\gamma)^t}{A} - p_j(t))$.

Once again $p_j(t)$ is the j-th community member size of expenses on consumption of the last unit of public resource, that is, individual marginal value of the resource.

If the size of *p(t)* is or eventually becomes negligible in comparison with $\frac{B_0 \cdot (1+\gamma)^t}{A}$, then the formula (4) may be transformed to the form of

$$V_L^j(t) \cong \frac{\alpha}{\beta} \cdot \frac{B_0}{A} \cdot (1+\gamma)^t, \tag{15}$$

and the ratio to lower discounting factor for public resource marginal value will be $(1+\gamma)$. So the corresponding individual discounting rate will be near $r-\gamma$, where r is the discounting rate for conventional goods in social-oriented projects.

But now again if the number *N(t)* of community members grows in a geometrical progression

$$N(t) = N_0 \cdot (1+\nu)^t, \tag{16}$$

total public marginal value, which is now the sum of individual ones, grows as $\sim (1+\gamma)^t \cdot (1+\nu)^t$, and $(1+\gamma)^t \cdot (1+\nu)^t$ is corresponding lowering ratio, and discounting rate is near $r-(\gamma+\nu)$, that is discounting rate for conventional goods in social-oriented projects minus rate of growth of total public consumption.

Important remark. The important remark here is that nature protection projects not so much create ecosystem production and functions, as support and improve their reproducing. Hereupon exactly the consideration of marginal, instead of average values is valid for value of these goods relatively to conventional ones.

Interrelations with projects worsening environment conditions. In elaboration of statements about distinction of different kinds of discounting rates to bind it with necessity of compensations for natural ecosystems losses during realization of projects worsening environment conditions, we offer the following formula of settlement payments to ecosystems' proprietors or users from investors of such projects (the case of pure financial indemnifications is considered):

$$\sum_{i=0}^{T} P_i \big/ (1+\theta)^i = \Delta S + \frac{\Delta F}{\eta} + Ex. \tag{17}$$

Here *ΔS* are the losses of "environmental stocks". These are all kinds of the losses connected with lump-sum incomplete recycling of values, containing in destroyed natural resources, and also changes in components of the total value: option value, value of current existence and bequest value. *ΔF* are losses in "ecological stream", i.e. annual productivity of destroyed plus productivity reduction of disturbed ecosystems. η is the *natural* discounting rate for ecosystem goods expressed in unit fraction. *Ex* ("externalities") is a current estimation of the difference of the positive and negative external effects connected with the project realization. T is the planned duration of the project realization, i is the number of year of project realization, at end of which the payment P_i is carried out, P_0 is the project starting payment, $1/(1+\theta)^i$ is the i-th year discounting multiplier for financial indemnifications, and θ is the *financial* rate of discounting, taking into account the inflation.

Conclusions. Therefore as the main conclusion.

Continuous growth of human economic activities productivity and the constancy of natural ecosystems specific potential, difficulty of replacement and public character of consumption for their production and services lead to naturally occurring distinction for corresponding discounting rates.

The idea of special discount rates for the production and non-material services of ecosystems is useful both for economic efficiency assessment of nature conservation activities and for calculation of compensations from the activities worsening environment quality.

Mentioning a question on a perspective sphere of research, first of all, we note the necessity of specification of real indifference curves maps and of approaching functional dependences for typical individual and public (if exist) utility functions with inclusion as one of parameters for these functions the quantity of consumed production and services of natural ecosystems.

The account of risks at an estimation of investments may also become the important direction of development. As frame positions of such research we mention, that in conventional investment projects the account of failure or short-reception of benefits project risks during its realization leads to increase in the discounting rate for forthcoming values. On the contrary, in nature protection projects and projects affecting ecology, risk of irreversible ecosystems' losses, most possibly, should work aside decrease in rates of discounting of the corresponding values produced by ecosystems. Therefore distinction in risks of ecosystems' losses and in times of their self-regeneration should lead to spatial differentiation in corresponding discounting rates. Development of methods for quantitative estimation of corresponding effect is necessary.

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О.А. Котко

Необхідність спеціального дисконтування для природних ресурсів та екосистемної продукції і послуг при оцінці ефективності інвестицій

Метою статті є продемонструвати необхідність спеціальних природних ставок дисконтування при оцінці ефективності природоохоронних дій. У наш час для цих цілей найчастіше використовується соціальна ставка дисконтування, запропонована Д. Пірсом. Однак дотепер значна частина цінностей екосистемного походження має такі особливості як відсутність повноцінних замінників антропогенного походження і консервативний характер природних "технологій", а отже, просте, а не розширене відтворення. Як результат, виникає необхідність спеціальної норми дисконтування для незаміщуваних продукції та послуг, які *мають обмеження у можливостях їх відтворення і споживання, що може бути продемонстровано аналізом траєкторії вибору в ході росту споживчого бюджету поверх рівня, на якому досягається максимум споживання обмеженого блага. Стаття дає оцінку скорочення норм дисконтування у припущеннях індивідуальних функцій корисності типу Коба-Дугласа і – для відновних природних ресурсів, що колективно споживаються, обмежених у можливостях відтворення – рівного розподілу споживання серед членів споживчого суспільства. Ідея застосування спеціальних норм дисконтування для продукції та нематеріальних послуг екосистем корисна як для оцінки економічної ефективності природоохоронних дій, так і для обчислення розмірів компенсацій за проведення дій, що погіршують якість довкілля.*

Ключові слова: дисконтування, природна ставка дисконтування, інвестиції, екосистемна продукція, екосистемні послуги, ефективність природоохоронної діяльності.