Does the time inconsistency associated with hyperbolic discounting undermine long term planning?

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Abstract: The paper discusses the question of time inconsistency related to hyperbolic discounting. It shows that under some not very unusual conditions, long term government programs can be associated with a desirable time inconsistence, making the net present value maximising government more keen on completing the program as it proceeds. On that background the special profile characteristics under which the time inconsistency associated with hyperbolic discounting can be ignored are identified and discussed.

Exponential versus Hyperbolic Discounting

A crucial component of public sector planning is the way to deal with time preference, the analytical representation of which, are discount functions. A government program that reaches its objectives ten years earlier than alternative program *ceteris paribus* is usually preferred to the alternative program. Even if all quantifiable effects are identical. Discounting makes the difference.

In the academic discussion about the best way to deal with time preference, alternative discounting methods are put forward. The most prominent topic in the current debate is whether exponential discounting or hyperbolic discounting is the best way to represent our collective preferences, i.e., the preferences relevant for government decisions. Exponential discount functions are of the form $(1+r)^{-t}$, where r is the discount rate and t is the point of time. The constant rate of discount ensures that the relative decline in present value from any point in time T to T+1 is the invariable. Hyperbolic discounting, on the other hand assumes that r is a declining function of t. This means that hyperbolic discounting doesn't reduce the present value of economic values in, say, 100 years as much s exponential discounting does.

One line of argument maintains that there should be no difference between individual and collective preferences. That goes for time preferences as well of preferences for goods and services. According to this view, the collective preferences can be derived from the individual preferences as median voter preferences (or similar) or as the sum of consumer preferences revealed in market behaviour or stated in contingent valuation studies. Much of the economic literature views the latter as superior to the former because it can establish the social value of actions independently of politics and transitional fluctuations in values. You can establish a direct logic from the market rate of interest to the time preferences of the representative individual on which you can base your discounting in public planning.

This line of argument is countered by empirical studies that find the actual behaviour of individuals to reflect hyperbolic rather than exponential discounting. Se Frederick, Loewenstein et al. (2002) for a review. If there should be no difference between individual and collective time preferences, then there is an empirically founded case for using hyperbolic discount functions to reflect collective time preferences since they actually reflect individual time preference quite well.

Empirical studies by among others Cropper (1992) have also found evidence of hyperbolic discount rates representing collective time preferences better than exponential.

Another line of argument maintains that collective preferences are not necessarily derivable from individual preferences in this simple sense. Individuals are not only consumers, they are citizens as well. As far as time preferences are concerned, they may have other preferences as citizens than they can possibly have as consumers. Market behaviour is formed by well known economic phenomenons like free-riding behaviour and the laws of competition. These are, however, irrelevant as basis for collective preferences. Consumers may adhere to exponential discounting only because they have to survive on the market, but governments are not subject to the same constraints.

The second line of argument goes back to the classical economists and in particular to Pigou (1950[1920]): "But this preference for present pleasure does not - the idea is self-contradictionary - imply that a present pleasure of given magnitude is any *greater* than a future pleasure of the same magnitude. It implies only that our telescopic faculty is defective, and that we, therefore, see future pleasures, as it were, on a diminished scale." What comes out of this, Pigou calls "our irrational discounting" (p. 29). Reffering to an example put forward by Giffen, this "irrational discounting" is to blame for the lack of infrastructure investments such as a tunnel between Ireland and Great Britain, water supply, and afforestation. The same applies to a number of examples of non-sustainable use of natural resources: To rapid exploitation of the most accessible coal reserves in a way that make the poorer reserves less accessible, fisheries without thinking of the reproduction of the fish stock, agricultural methods that reduce soil fertility, and excessive energy consumption in sea transport.

Ramsey (1979[1928]) found that discounting over generations separated in time "is ethically indefensible and arises merely from the weakness of the imagination." (p. 261).

Today, economists critical to discounting practices are less categorical than Pigou. It is not discounting *per se*, but excessive discounting that makes long term programs seemingly uneconomic. The problem in the examples mentioned by Pigou is not discounting, but discounting at too high a rate, in particular in the very long run, and neglect of the scarcity of natural resources as well as of non-marketed services of the investments.

A sharp formulation of this was provided by Chichilnisky (1997) referring to policies based on exponential discounting with consequences for future generations as the dictatorship of the present over the future. However, policies based on zero discounting would represent a dictatorship of the future over the present.

The problem can be illustrated by a stylised a long term investment program shown in the figure below.

Figure 1. Discounting a Long Term Program with 7% Discount Rate.

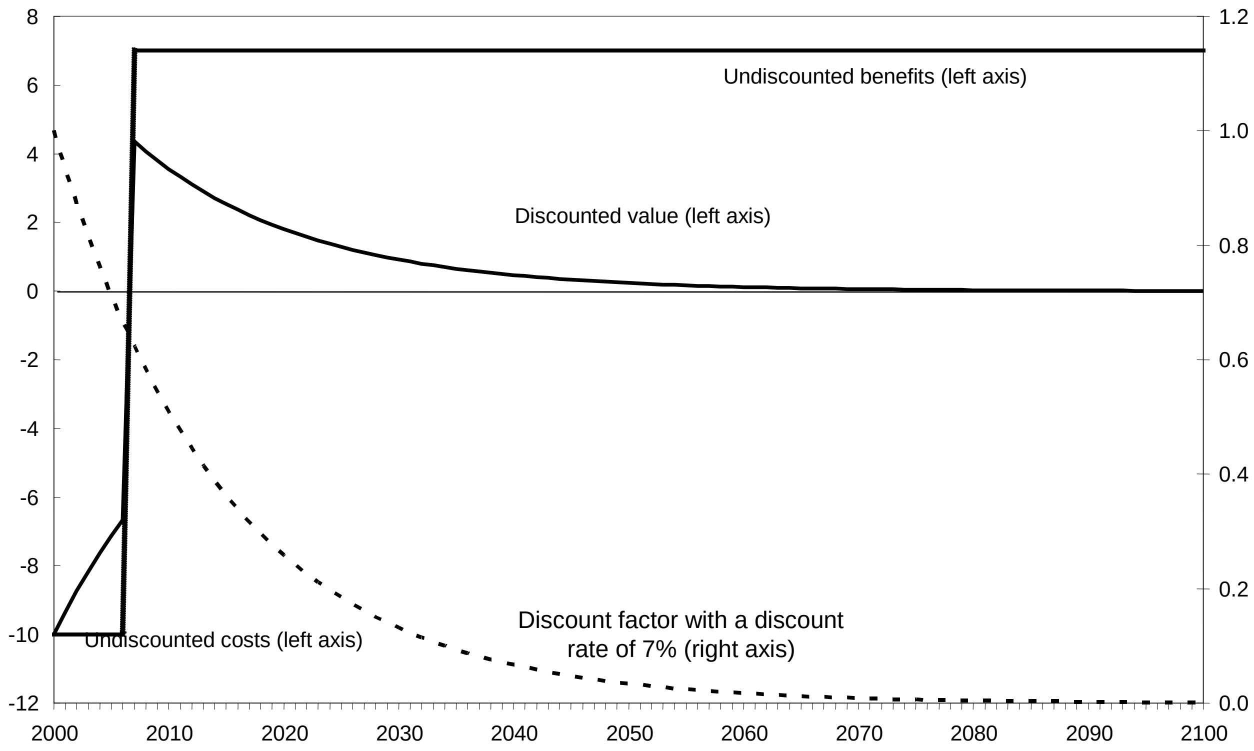


Figure 1 shows the undiscounted costs and benefits, the discount function and the discounted costs and benefits of a programme in a one-century time frame. The undiscounted costs are 10 units annually for 7 years and the undiscounted benefits are 7 units annually for the remaining 93 years of the century. The discount function is based on a 7% constant discount rate as recommended for tax financed projects by the Danish Ministry of Finance (Finansministeriet) (1999)

The table below shows the net present value (NPV) for this profile and for a slightly altered profile where the years of investment is extended by one year and the years of benefits correspondingly reduced by one year. It also shows NPVs for two alternative profiles: one where the stream of benefits ceases in 2070 and one where it ceases in 2500.

Table 1. Net Present Value in Year 2000 of a Stylised Program by Profile and Discount Rate

Years with investment (10 units/yr)	Years with benefits (7 units/yr)	Rate of discount	
		7%	1%
7	63	8.1	242.7
7	93	8.9	332.7
7	493	9.0	586.6
8	62	-2.5	226.8
8	92	-1.7	316.8
8	492	-1.6	570.8

The table shows that with a 7% rate of discount, the break even point is between 7 and 8 years of investment. The profile displayed in the figure consist of period of 7 years with investment of 10 units per year followed by 63 years of benefits of 7 units annually gives only just a positive NPV at 7%. If the stream of benefits is extended by 30 years to a total of 93 years, the NPV only changes slightly. If further 400 years of benefits are added, it has almost no effect on the NPV.

It is a counter intuitive result that it should make no difference whether future generations for 400 years could enjoy this stream of benefits without any costs. However, it repeats itself if the profile of the program is lightly altered. The investment period is now extended to 8 years, leaving only 62 years with benefits. That is enough to shift the sign of the NPV. If the period of benefits, still 7 units per year, is extended by 30 years, the NPV is affected positively, but remains negative. If the stream of benefits is extended by another 400 years, it has no important influence on the NPV. You might add that the same would be the case if the stream of benefits was extended to eternity.

One solution would, of course, be to choose a lower discount rate for programs with far future objectives. In the table, the NPVs of the same profiles are shown for discount rates of 1%. They are far more intuitive.

This is also the preferred solution to a number of economists and government agencies, dealing with very long term investments. For instance, the US-EPA (2000) recommends *intra*generational discounting in the range of 1-7% and *inter*generational discounting in the range of 0.5-3.0%. It is, however, not explicit how far the *intra*generational perspective reaches.

The obvious weakness of this approach is, however, that even programs with perspectives reaching several hundred years in the future, involves costs and possibly benefits too in the near future. They have to be dealt with in the same way as near future oriented programs, and then we have two different rates of discounting and no scientifically founded guidelines for which to use when.

This puts on the agenda a search for a scientifically founded approach to discounting hyperbolically. That is, with a gradually declining discount rate.

Hyperbolic Discounting and Time Inconsistency

The Chichilnisky sustainability axiom of no intergenerational dictatorship has been taken a step forward by Heal (1998) suggesting that *logarithmic discounting* could be a candidate to a such a discounting approach consistent with this sustainability axiom. Logarithmic discount functions that should be more or less consistent with the rates that prevail in the near future would start in the region of 20% or more and then gradually decline.

Another suggestion was presented by Weitzman (2001) who derived a discounting approach based on the logic that since the future rates of economic growth by which discounting eventually lends it legitimacy, there is an increasing uncertainty about the future discount rates, which eventually leads to a declining rate of discount as seen from the present. This approach is called *gamma-discounting* and a questionnaire to a worldwide sample of economists provided the distribution of anticipated constant discount rates on the basis of which, a discount rate starting at 4% and then approaching zero asymptotically.

Several other suggestions have been put forward but we shall not go into detail here, just note that the prospects of finding a scientifically founded basis for hyperbolic discounting are promising.

But even if and when this problem is solved, there is another argument against basing government programs on hyperbolic discounting: Even if hyperbolic discounting more correctly reflects individual time preferences, the differences in the “decay” of the discount function cause time inconsistency in the economic assessments of the programs and thus – if decision makers care about the assessments – makes it difficult to stick to any long term plan at all.

The section starts with clarification of concepts, results and positions in the debate. It then goes on to discuss the problem of time inconsistency in some Danish environmental action programs. It is shown that time-inconsistency in that type of public planning rather encourages than discourages reinforced efforts to complete the program. It is shown that it is a question of whether the benefits of the action program as a whole are identical with the sum of the benefits of its individual actions and whether the completed part of the program has the character of sunk costs. Finally, it is argued that long term programs for conversion to sustainable levels of environmental stress typically are of this kind.

What is time inconsistency and why is it a problem?

Time inconsistency occurs in the dynamic allocation of scarce resources. At the outset an optimal plan for consecutive actions in the future can be identified whereas at the time when these particular actions are to be executed they don’t seem optimal in that moment. This problem occurs for individuals and households as well as for firms and public authorities.

Strotz (1955) points to behaviour like *spendthriftness* and *thrift*. The neoclassical standard assumption of optimising agents based on unchanging indifference maps with twice differentiable and convex indifference curves excludes that kind of behaviour. Yet, it is quite common. To understand such behaviour, we have to replace this assumption with an assumption of two indifference maps – one for the long term and one for the instant.

At the individual level, everybody is familiar with commitments and temptations. Time inconsistency occurs when smokers that have decided to quit smoking, do it, when married couples are unfaithful, when you change your mind about getting early up in the morning, and in myriads of other daily incidences.

Utility and profit maximisation go hand in hand with more general commitments in most decision making in the private as well as the public sector. Spending the pay check at pay day is hardly a temptation that is new to anybody, and a strong commitment is often necessary to get food on the table on a daily basis. Pension plans are other types of commitments that households and individuals have to make.

Households with good financial counselling may be able to decide on a savings and consumption plan that is optimal to them over a life span of time. The question is whether they will stick to it when their life takes unexpected turns. Therefore nobody make such plans without large margins and considerable modifications so the risk of violating the plan when following their short term interests is minimised.

Government policy is inherently subject to shifts in preferences due to the replacement of governments, which is the idea of democracy, the pressure from interest groups on governments that don't want to be replaced, and to the shifts in the preference structure of the general public. There is also time inconsistency involved in more subtle strategic action in government policy. In monetary and exchange rate policies, for instance, the credibility of the policy is very important and it can be costly in the long run to give in for temptations in the short run.

There are two strategic response options to the problem of time inconsistency. One is to engage in *precommitments* that reduce the opportunities to give in for temptations. Strotz (1955) refers to Olysses, asking his men to tie him to the mast as they passed the island of the sirens. This is a metaphor that the literature has returned to repeatedly. It is commitment and temptation in a nutshell.

The other option, Strotz (1955) calls *consistent planning*, that is, to plan so that it will be optimal to execute the planned future actions. A relevant objection here would be that consistent planning is not necessarily an alternative to precommitments, but rather an attempt to narrow down the distance between the planned course and anticipated temptations. Precommitments also have to be realistic in this way if they should have any effects at all.

The notion of precommitment has connotations to Simon's limited rationality, the rules of thumbs that are followed, and the behavioural norms that are complied with. There is hardly any doubt that it represents much of the economic behaviour of individuals, households, and firms. But what about governments? As noted above, they shifts several times during a, say, 50 year program. That is the idea of democracy, so the collective preferences, they represent, are likely to shift as much. Democracy is inextricably bound up with time inconsistence in government policies.

Governments have on the other side their own forms of precommitments. The first that comes into mind are politically broad coalitions of political consensus behind central policies and strategies such as defence policy, pension policy etc. If the potential next government is included in the consensus, such policies can last beyond the ruling government. Another form of precommitment is international agreements with threat of sanctions if they are not complied with. Trade agreements, regional political agreements, defence agreements, etc.

According to the theory of political economy, there is also an important mechanism that reduces the need for precommitments in some cases. The rents associated with a particular set of policies and regulations create the rent-seeking and vested interests that provide the support for that set of policies. If the reform process succeeds, the centre of gravity in the economic interests also moves in the direction of the new set policies.

Thus, government policies must be expected to be time inconsistent, but there are remedies to disposal in national as well as international political practice too. As noted by Heal (1998) it seems to demanding to require full time consistency of individuals and certainly of governments too.

Is Time Inconsistency Associated with Hyperbolic Discounting a Problem ?

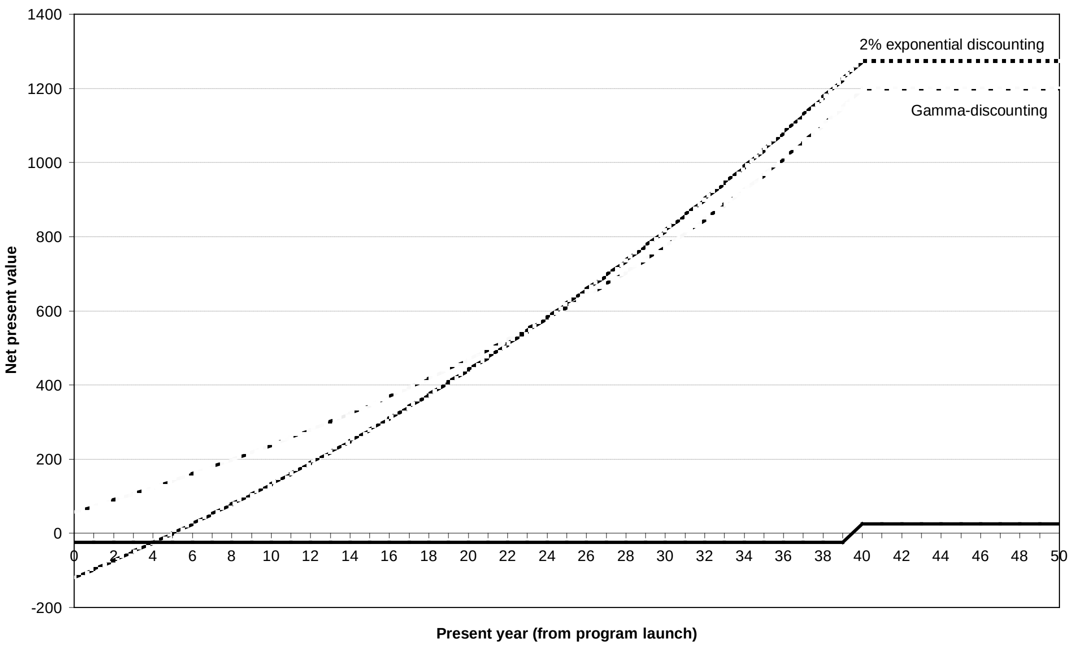
How much would hyperbolic discounting push the balance between time inconsistency and precommitments in the direction of time inconsistency?

Not much. On the contrary, in programs involving conversion of patterns of economic behaviour and associated infra structure and technology development costs, the time inconsistency caused by the changing instantaneous discount rate from the point of planning to the point in time of execution actually favours the completion of the program.

If we assume a program involving given total investment (investment costs, switching costs, innovation costs) resulting in a given benefit after completion of program, the net present value of the benefits after completion of the program will increase as the program proceeds. At the same time, the investments done at any point of time during the program can be considered sunk costs. Thus, the remaining costs to obtain the final reward will be less compared to the initial time of planning. Both of these forces contribute to stronger economic interest in completion of the program.

The figure below illustrate this for a program with an investment period of 40 years where 25 units are invested annually followed by a benefit stream of 25 in the following 450 years

Figure 2. Net Present Value of 40 Year investment Program (Costs of 25 a Year) Succeeded by Benefits of 25 units a year in the following 450 years. Exponential and Gamma Discounting with Moving 400 Years Horizon.

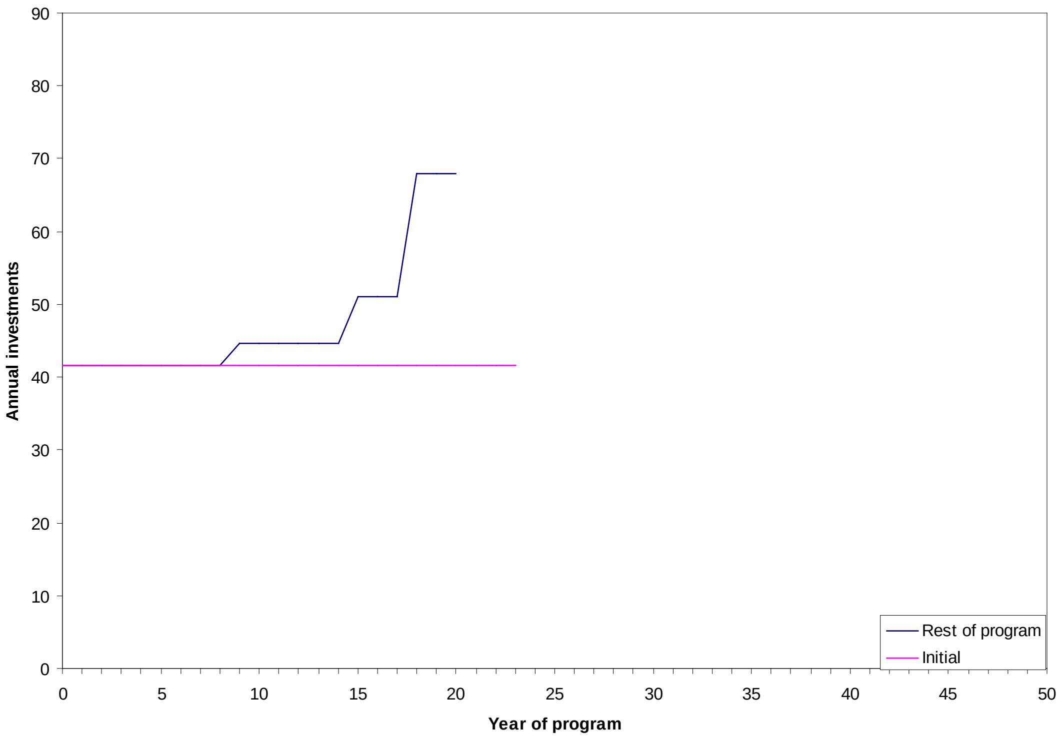


Even with a low exponential discount rate, the program would never be launched without a commitment to long term planning based on another rationale than maximizing exponential-discounting net present value. That is, it should be launched based on some considerations for future generations that can not be quantified and included in a cost benefit calculus. However, as time passes the already invested costs of 25 per year become sunk costs the remaining costs get closer, and the present value of the benefits increases. After five years no additional commitment is necessary because it becomes less expensive to complete the program and reap the benefits. Already after 5 years, the NPV becomes positive and further precommitments are unnecessary as far as

Hyperbolic discounting, here represented by gamma-discounting, is in no way more subject to time-inconsistency. It shares the same feature of less cost to achieve the same benefits that increase in their net present value as they approach the present. On the contrary, the time inconsistency is less, since the program was already optimal in the outset of the program. The considerations for future generations are quantified as a particular form of the discount function.

Another view on the same phenomenon is the optimal time span for completion of the program as the program itself proceeds. This is illustrated in the figure below. Here we have used a total investment of 1000 units to be invested over the investment program and a 25 unit annual benefit in the 250 years after completion. Only hyperbolic discounting is used, based on a 22% logarithmic discount function.

Figure 3. Optimal Investment Effort in the Remaining Investment Program (1000 units total investments, 10 units benefits in 250 years after completion, 22% logarithmic discounting)



The straight line is planned annual investments at the outset of the programs.

The calculations behind the curve in go on step further than those behind figure 2 as it is calculated how fast an NPV-maximising government would like to complete the program and subsequently how much it would like to invest every year. Time inconsistency in this case is not a question of long term policies being scrapped, but rather of governments being increasingly eager to complete the program.

There are two crucial conditions of the program illustrated in the figure above, that result in this type of “desirable” time inconsistency. First, the program represents a cost-benefit profile where the benefits are not reaped instantly as the costs are defrayed, but as a result of the completion of the entire program. This is the case when the opportunities can represented by a non-convex set of programs. For instance, either you have a new technology or drug, that can solve the problem or you have not. That is, you can not get a continous pay-off curve as a function of a moving set of weights to existing realizable plans.

Second, the costs must be considered sunk costs when they are paid. Otherwise, they enter the NPV calculation as costs again.

In real world program, of cause, both characteristics are mixed up with other profiles and conditions. Thus, the question is whether these conditions for desirable time inconsistency dominate the other profiles and conditions in the program to such an extent that desirable time inconsistency prevails or at least that the undesirable time consistency is not more outspoken than it can be dealt with by available precommitment arrangements.

The programs for conversion of the production patterns of industries and the consumption patterns of households to environmentally sustainable ones are likely to have these properties. The initial attempts phases of the environmental action programs was very much focused on a more economic use of inputs such as energy, nitrogen in pig fodder, chemicals in service and manufacturing, etc. In that way it has been possible to follow a win-win strategy, saving input costs and environmental qualities at the same time. It would be too premature to consider these no-regret options to be exhausted, even in Europe, at this time, but many of the recently adopted sustainability strategies in Europe are, at least at the programmatic level, more focused on a more long ranging decoupling of environmental pressure from economic growth.

It is hardly possible to fulfill such ambitions without developing entirely new technologies and infra structures to encapsulate the environmentally harmful substances and lead them into a harmless recirculation or even replace them by harmless substances. Such technologies and infrastructures could include the recycling of pig manure in separation plants, the plans for restructuring of the automotive transport system based on hydrogen produced by CO_2-neutral technologies. If such future decoupling developments are considered programs, they share the profile characteristics of the examples above: The benefits are not available until the competitive technology is developed. From that time of, it is available forever, and probably useful for several hundreds of years. The costs invested in the innovation are definitely sunk costs.

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