# Appropriate discount rates for long term public projects

Kåre P. Hagen, Professor
Norwegian School of Economics
Norway

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# Assessing long term public investments

## Choice of discount rates

kare.hagen@nhh.no
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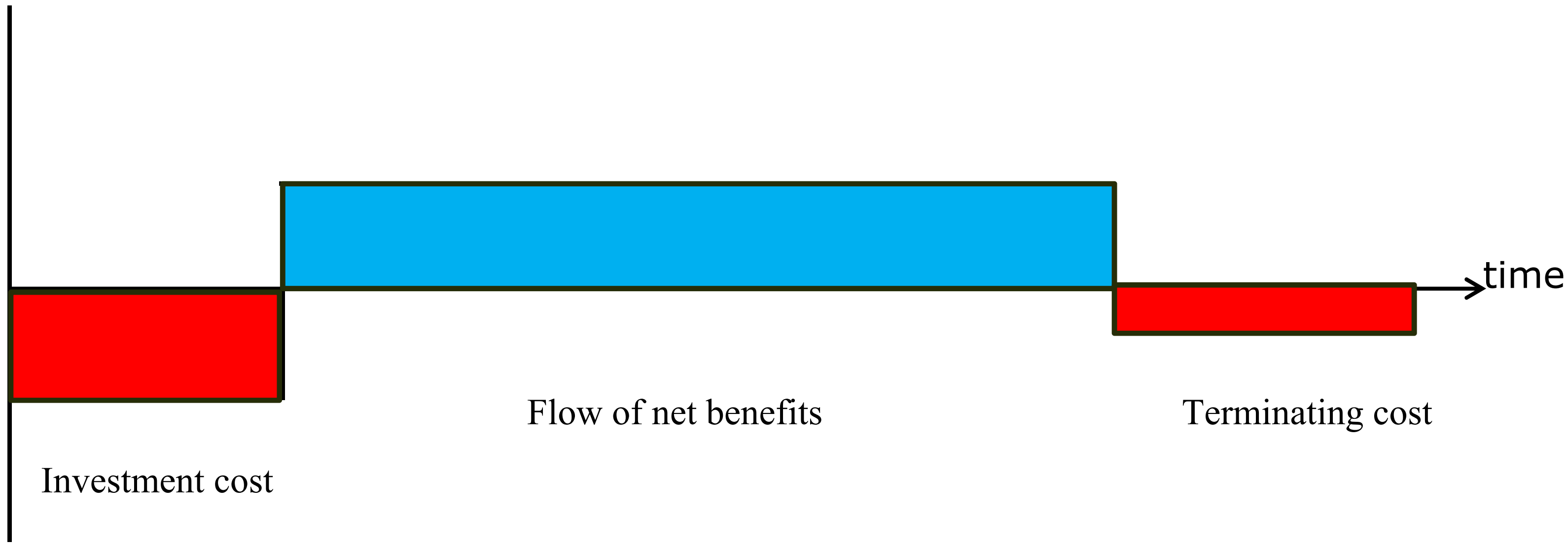
## Assessing long term projects
### Valuing the future

- Long term investment projects
  - Initial outlays during the investment period
  - Flow of net benefits during the operating period
  - Terminal value at the end (may be negative)
  - Long term environmental costs (may be irreversible)

- Economic assessment requires adding together consequences occurring at different times, and normally with very different time spans.
  - For this we need a common monetary metric (unit of account)
  - Our monetary metric will be the present value
    - The present value is the cash equivalent of future values obtained by discounting future values to time 0 as a common reference point
    - Future values are assessed in terms of present values by means of discount factors
    - $1/(1+r)^t$ = the present value of a monetary unit due at time t

## Stylized time profil for a long term investment



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## Historical background

- Discounting and the concept of present value can be traced back to accounting procedures by monks in Italian monasteries in the 12th century.

- Economists in the middle ages recognized that the discount rate is an implicit price determined by the values of transactions taking place at different points in time .
  - Discount houses appeared in the latter part of the 15th century as a response to financing foreign trade.
  - The discount was considered as an agreed upon price by an impatient merchant and a patient broker for the expected delivery of goods over a finite time horizon.

- That individuals discount the future is by no means a recent observation
  - Discounting leads to myopic behaviour
  - Comments on myopic behavior may be traced back to Plato in his *Laws* and discussed by later philosophers like John Locke and Jeremy Bentham.
  - In recent times these early insights have been confirmed by psychological experiments.
  - Experiments aimed at deriving the time preference of animals have revealed hyperbolic discounting behaviour

## The consequences of discounting the future

- By discounting, future values are expressed in equivalent present values
  - The present value of one krone due in t years from now is $1/(1+r)^t$
  - With r = 10%, the present value of one krone due in 10 years is .38, and .008 in 50 years, and negligible after 100 years.
  - With 5% we have . 61 after10 years, .08 after 50 years, and .007 after 100, respectively

→ "Tyranny of discounting"
  - Discounting is shortening the relevant economic time horizon of the project
  - In economic models of resource allocation over time, the objective function is normally the discounted sum of utiltiies

$$W = \sum_t (1+\delta)^{-t} U(c_t)$$

- Prominent economists in the past considered discounting future pleasures as immoral
- Pigou (1920):… "it implies a defective telescopic faculty, …., and therefore we see future pleasures, as it were on a diminishing scale"
- Ramsey (1928): "… we do not discount later enjoyments in comparison with earlier ones, a practice that is ethically indefensiveble an arises merely from the weakness of imagination".
- Harrod (1948): " …. Pure time preference is a polite expression for rapacity and the conquest of reason by passion"

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## Some basics on discounting:
## Discount rates represent opportunity cost of capital

- Discounting future values makes it possible to compare the monetary value of economic consequences occurring at different times
  - Discounted to the present time, discounted values are called present values or cash equivalents.
    - For a given income stream over time one would be indifferent between this stream or its present value calculated at the market rate of interest.
    - Example:
    - You sell your car for 110.000 and it is agreed that the payment will take place in one year.
    - If the market rate of interest is 10%, the present value of this contract is 100.000

- Discount rates as opportunity costs
  - A business person invests 10 mill of his equity in new production plant. What is the opportunity cost caused for this investment?
    - The answer is that it is given by the returns on the most profitable investment alternative foregone, say 15%
    - The returns on the actual investment must at least match 15% in order to be profitable
    - → Opportunity cost of capital is then the hurdle rate of return for the actual investments alternative.
    - That applies to private and public investments alike

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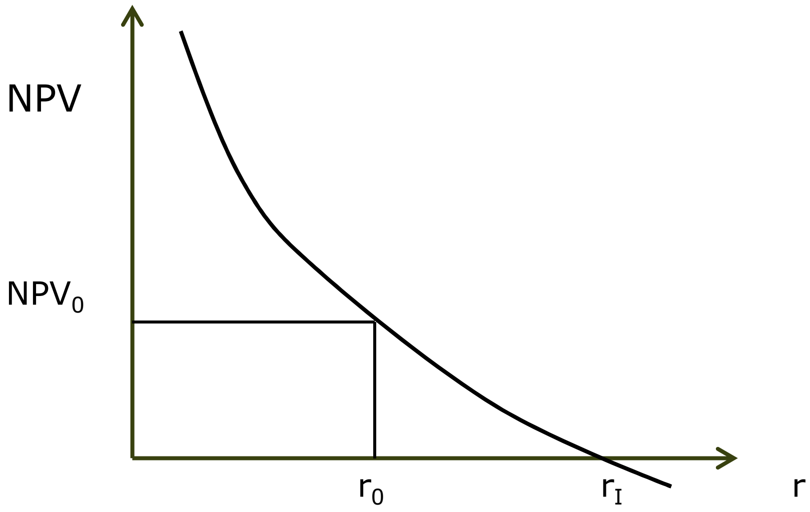
## Rate of return requirement for a profitable prosject

- Assume a project with investment I and net pay offs given by $x_1 \dots x_T$
- Its net present value is then given by

$$NPV = \frac{x_1}{(1+r)} + \dots + \frac{x_T}{(1+r)^T} - I$$ where r is the discount rate

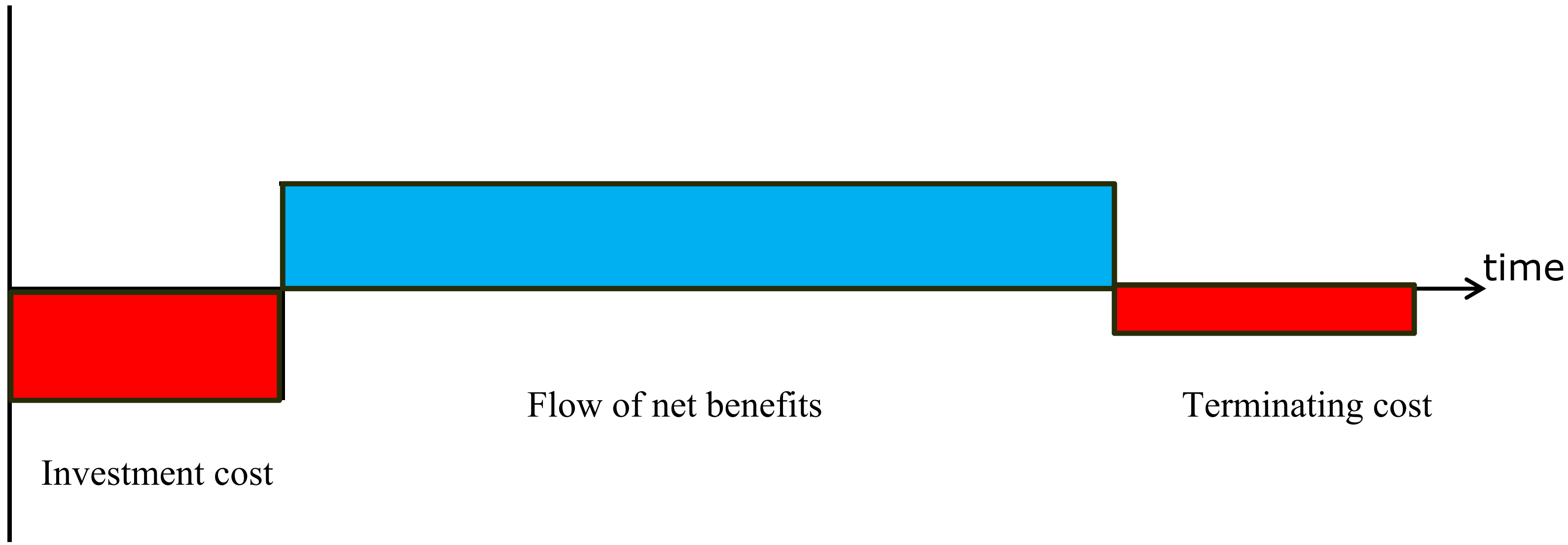
Net present value is a decreasing function of the discount rate.




- $r_I$ = the projects's internal rate of return
- $r_0$ = discount rate equal to the opportunity cost of capital
- Net present value larger than zero implies that the project's internal rate of return is larger than the opportunity cost of capital

## Stylized time profil for a long term investment

Assume it is an nuclear power plant where terminating costs are decommissioning costs




A higher discount rate means lower present value of terminating costs an might even increase its net present value.

Should perhaps be seen as three projects

An investment project

An operating project

A  decommissioning  project

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## Two Approaches to the optimal discount rate for public investment Consumption based or market based.

- Consumption based. Frank Ramsey: (1928)
- $r_t^* = \delta + \gamma \dot{c}_t$

$r_t^*$ = rate of return requirement at time t for a krone saved now (at time 0)

$\delta$ = the rate of pure time preference

$\dot{c}_t$ = relative change in consumption from 0 until t

$\gamma \geq 1$ is a factor expressing the consumer's aversion to uneven consumption over time

→ Consumption growth implies a higher discount rate and less willingness to save for the future

→ With consumption growth less willingness to save the higher the aversion factor $\gamma$ to uneven consumption

→ With a consumption decrease, there will be increased saving due to the aversion factor and a lower discount rate

- In a generation perspective $\gamma$ represents the aversion to treating generations differently

- Example: The recommended discount rate in the Stern Review on the Economics of Climate Change.
- Low rate of return on long term climate investment mitigating the effects from global warming
- $\delta = 0.1\%$, $\gamma = 1$, $\dot{c}_t = 1.3\% \rightarrow r_t^* = 1.4\%$

## Rate of return requirement:
## Market based (Irving Fisher, Theory of Interest, 1932)

- The alternative to binding capital in a specific real investment project is here assumed to be an investment in the external financial market.
  - According to Fisher, the appropriate discount rate is the market rate of interest.
    - If the market rate of interest were higher than the rate of return on the real investment, the investor would gain by investing the capital in the financial market.
    - If so, should the public sector act as a private investor and invest in the foreign stock market in stead of domestic infrastructure?

- A basic problem with the market approach is that we do not have future markets for financial investments with longer duration than 35-40 years.

  →We cannot derive the opportunity cost of long term capital investment (40 years +) from the markets for financial futures.

  →That means that the long term market rate of return must be based on assessments

  → There will be uncertainty about market interest rates in the distant future

  → The discount rate will depend on the assumed stochastic processes underlying the future movement of interest rates over time

## How should we discount for both time and risk?

- The underlying assumption is that public decision makers acting on behalf of society have risk aversion
  - That means that a utility loss due to a certain reduction in consumption from a given level is larger than the utility gain from an equal increase.

  →The downside are weighted more heavily than the upside

  → will there require an economic premium for accepting to bear risk.

- Two types of risk
  - Uncertainty about the future economy
    - Uncertainty about the future interest rates and opportunity costs
    - Uncertainty about future consumption and social wellbeing
  - Project risk
    - Uncertainty about the project's contribution to economic values and welfare

# Uncertainty about the economy

- Uncertainty about future consumption.
  - If consumers have risk aversion, uncertainty about the future initiates an insurance motive for transferring resources to the future.
  - That takes place through precautionary saving.
    - Increased saving takes place through a reduction in the consumer discount rate
  - Moreover, if the uncertainty about future wellbeing is increasing with time, that would justify a decreasing time schedule for the discount rate.

- Uncertainty about opportunity costs as given by future market interest rates
  - Risk aversion means that the security equivalent discount rate is lower than the expected rate of interest.
  - If the risk as given by the spread around a given expectation is increasing over time, that would imply a decreasing time schedule for the market based discount rate.
- Hence, if uncertainty about the macro economy in the future is increasing with the time horizon, that points to decreasing discount rates
  - That applies both to consumer based and marked based assessment of discount rates.

## Project risk and the discount rate

- From the portfolio principle we that the project risk cannot be assessed in isolation.
- The risk must be assessed based on its contribution to the portfolio risk
  - Must assess the project's contribution to the risk of society's total portfolio of investments.
    - →The effective project risk depends on the correlation between the project's net monetary benefits and the benefits from the total portfolio (net national income)
    - This is called the project's systematic risk
    - If no correlation, the project specific risk does not add to the total social risk as it is unsystematic
    - Perfect correlation implies that the net benefits from the project should be discounted at a risk adjusted rate equal to the expected rate of returns on the total portfolio
    - A negative correlation implies that the project is functioning as a hedge for the total portfolio indicating a discount rate lower than the riskless rate of interest

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## The public discount rate in Norway: A brief history

- Until 1967 no discounting: No general requirement as to the rate of return on public investments
  - May be explained by the fact that capital was rationed after the second world war.
    - The allocation of capital more dictated by political priorities rather than by market conditions
  - In 1966 (the late) professor L. Johansen was commissioned by the Ministry of Finance to give a recommendation as to the optimal public discount rate in Norway
    - Based on the Ramsey formula he suggested 10 % ($\delta$ = 1%, $\gamma$ = 3, $\dot{c}$ =3)
    - It was revised in 1977 down to 7%
- In 1997 a government appointed committee recommended that the public sector should discount both for time and risk
  - The recommendation was to price risk in the same way as in the stock market
  - Risk adjusted rate of return requirements given by the riskless rate of interest, plus risk adjustment determined by the project 's systematic risk
  - The risk component given by the market's risk premium times the project risk.
    - The systematic project risk given by the correlation with the total market portfolio ($\beta$-value)
    - $r^* = r + \beta(R-r)$.
    - Example: $r^* = 2\% + ½(6-2)\% = 4\%$

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## Hyperbolic time preferences and discounting.

- Experimental studies and observations indicate that our short term behavior deviate from our long term intensions.
  - We are more sensitive to postponing consumption in the near future than in the long run
  - We will have pleasures sooner rather than later, and inconveniences later rather than sooner
  - Example: I may prefer one apple today to two apples tomorrow because of a strong time preference, whereas I would prefer two apples in 51 days to one apple in 50 days.
    - This implies that seen from time 0, my rate of time preference is declining over time
  - Some people are arguing that hyperbolic time preferences is in itself a valid argument for a declining discount rate time schedule.
    - It may, however, cause dynamic inconsistency. Plans that are optimal seen from time 0, may not be optimal, say, at time t >0.
    - Dismantling long run investments, say in railway infrastructure, just because your time preferences are changing with the passing of time, does not seem sensible.
    - We should rather look for binding mechanisms so that we can resist such temptations.
  - Another type of behavior explained by hyperbolic time preferences is procrastination
    - Example: I will stop smoking next week, but not today.