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Discount rate in project analysis

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The discount rate and the current practice

Discounting is the usual method permitting to compare the future value to a present value. This is a key parameter of the socio-economic evaluation of public investment projects that have impacts for the distant future.

It is observed that the use of discount rate in the project analysis is very different in different countries. This is particularly the case between the United States, the United Kingdom and France.

In the **United States**, since 2003, the Office of Management and Budget (OMB)[1], depending on the US presidency, recommends that project costs and benefits be discounted at two constant rates: 3% and 7%[2]. The first is the average return to 10 year government bonds, taken as an estimate of the social rate of time preference. The second is the average before-tax rate of return to private capital, taken as an estimate of the opportunity cost of capital.

In the **United Kingdom**[3], the discount rate is based on the Ramsey formula ($\alpha = \delta + \gamma\mu$) and declines over time. The first term ($\delta = 1.5\%$) is interpreted as a combination of pure time preference and risk of catastrophe (under which the future effects would be eliminated or severely altered). The elasticity of marginal utility of consumption (γ) is set to 1 and the economic growth rate (μ) estimated as 2.0%, yielding a discount rate of 3.5% (1.5% + 1*2.0%). For longer term beyond 30 years, the UK guidance specifies a step-wise decreasing discount rate motivated by uncertainty as shown in the following table up to 300 years:

Period of years	0-30	31-75	75-125	126-200	201-300	301+
Discount rate	3,5%	3,0%	2,5%	2,0%	1,5%	1,0%

Sources: Green book Appraisal and Evaluation in Central Government.

In **France**, the Lebègue Report (2005)[4] recommended a rate of 4% up to 30 years and decreasing to 2% beyond 30 years. The 4% rate is obtained by applying the Ramsey formula with pure time preference rate $\delta = 1\%$, elasticity of the marginal utility consumption $\gamma = 2$ and economic growth $\mu = 1.5\%$. Currently, the French discount rate is set by the Quinet Commission (2013)[5] which recommends a risk free discount rate of 2.5% to 2070 and gradually declining to 1.5% beyond 2070. A risk premium, specific to each project, is added according to its macroeconomic sensitivity (β) and

[1] https://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/a-4.pdf
https://www.whitehouse.gov/sites/default/files/omb/assets/a94/a094.pdf

[2] The rate was 10% in 1980s and was revised to 7% in 1992. The rate of 7% was retained in 2003 circular.

[3] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

[4] http://www.pierrekopp.com/downloads/2005%20Rapport%20Lebegue%20Taux%20actualisation%2024-01-05.pdf. Before the Lebègue Report (2005), the real term rate was 8%, in relation with a marginal capital profitability of 6 % plus a systemic risk premium of 2%.

[5] http://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/archives/CGSP_Evaluation_socioeconomique_17092013.pdf

systemic risk premium which is set to 2% up to 2070 and 3% beyond 2070. This choice reflects the markets' behavior, the macroeconomic considerations and intergenerational concerns for the long term. When the macroeconomic sensitivity (β) of a project is not known, the Quinet Commission recommends the rate of 4.5%.

As of December 31, 2016, 44 public investment projects (of which the investment costs are more than 100 million euros) were submitted to the CGI for a socio-economic contra-evaluation. The analysis of these projects shows that few cost benefit analyzes were undertaken outside the transport sector. And for the transport sector, the discount system was frequently used with the betas recommended by Quinet commission: 0.5 for investment, 1 for carbon value, 1.1 for urban passenger transport, 1.2 for regional passenger transport, 1.7 for long distance passenger transport and 1.4 for freight transport.

A long discussion on the discount rate[6]

The Ramsey formula as a basis for discounting

The Ramsey formula (1928) is the theoretical basis for the discount rate. Under this formula, the risk-free discount rate reflects:

- The pure time preference for the present, meaning preference for immediate well-being compared with a same wellness in the future;
- The wealth effect which, via an anticipation of consumption growth, leading to grant in the future less value to a current gain. The marginal utility of consumption being decreasing with the level of consumption, the fact that the consumption level is increasing over time implies that an additional euro in a year has a lower value than the euro today.

The extended Ramsey formula taking account of uncertainty and the declining discount rate

The uncertainty of the per capita consumption on the long term implies that we postpone part of our consumption to the future. This precautionary effect reduces the discount rate and gives more weight to the future. By integrating the uncertainty, we obtain the extended Ramsey formula.

The relationship between the discount rate and the time horizon is thus impacted by two effects: a wealth effect that encourages the current generation to spend more and the precautionary effect that encourages spending less. The result of these two effects is not straightforward. With the uncertainty about future consumption per capita, the discount rate is no more constant over time. It decreases following the various parameters of future consumption growth rates and less quickly over time to reach a limit value[7].

This theoretical conclusion led a panel of 12 economists (including Kenneth J. Arrow, Christian Gollier, William Nordhaus, Thomas Sterner and Martin L. Weitzman) to recommend to take a declining discount rate for USA at a workshop (whose conclusion[8] was published in 2014 in the journal "Review of Environmental Economics and Policy"), organized by US EPA (Environmental Protection Agency), in September 2011.

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[6] Gollier et Hammit (janvier 2014 The long run discount rate controversy (http://www.tse-fr.eu/sites/default/files/TSE/documents/doc/by/gollier/long_run_discount.pdf)

[7] Rapports Lebègue (2005) et Golier (2010)

[8] Should Governments Use a Declining Discount Rate in Project Analysis? (http://reep.oxfordjournals.org/content/8/2/145.full.pdf+html)

Taking into account the risks in project analysis

The risks of a public investment project with uncertain future benefits and costs in the distant future are of two types: systemic risk depending on the uncertainty of future growth and the non-systemic specific risk. The consideration of systemic risks in the cost-benefit calculation can be appreciated by integrating a probability distribution of a large number of macroeconomic scenarios. The expected value of NPV (Net Present Value) of a project can then be calculated. We can try to find a discount rate to give the same expected value. This resulted discount rate is the sum of risk-free rate and the risk premium.

In case where scenarios are not too different from the growth reference scenario, the beta method can then be applied with systemic risk premium multiplied by the socioeconomic beta of a project. The systemic risk premium measures the additional profitability expected for an investment whose benefits are affected by the same hazard as consumption per capita. The beta measures the sensitivity of benefits of the project to changes in consumption per capita. By definition, the net profit of the project increases by an average of ß% when consumption growth increases by 1%

The equity premium puzzle

By adding uncertainty of the future growth and applying the extended Ramsey formula, we get a very low systemic risk premium. Meanwhile risk premiums observed in the financial markets are rather high. This phenomenon is known as the equity premium puzzle. We can summarize this puzzle by saying that no level of risk aversion ratio is able, in a simplified model where the same parameter is used to measure agents' risk aversion and the intertemporal substitution effect, to get both low risk-free rates and high risk premiums.

One explanation for this lies in the fact that agents incorporate in their behavior low probability extreme risks. According to Gollier's works, the introduction of these extreme risks by Barro (2006, 2009) modifies the conditions of the standard model for estimating risk premiums with more robustness. In addition, the inclusion of catastrophic scenarios modifies not only the risk premium but also the risk free discount rate, since it also includes a factor related to the uncertainty of consumption growth. We need to treat simultaneously the risk premium and the risk-free discount rate. Both are strongly linked in what the Quinet Report calls the discount system.

Application of the discounting approaches US, UK and France to a real project

The three discounting approaches US, UK and France are applied to a real regional project in south France.

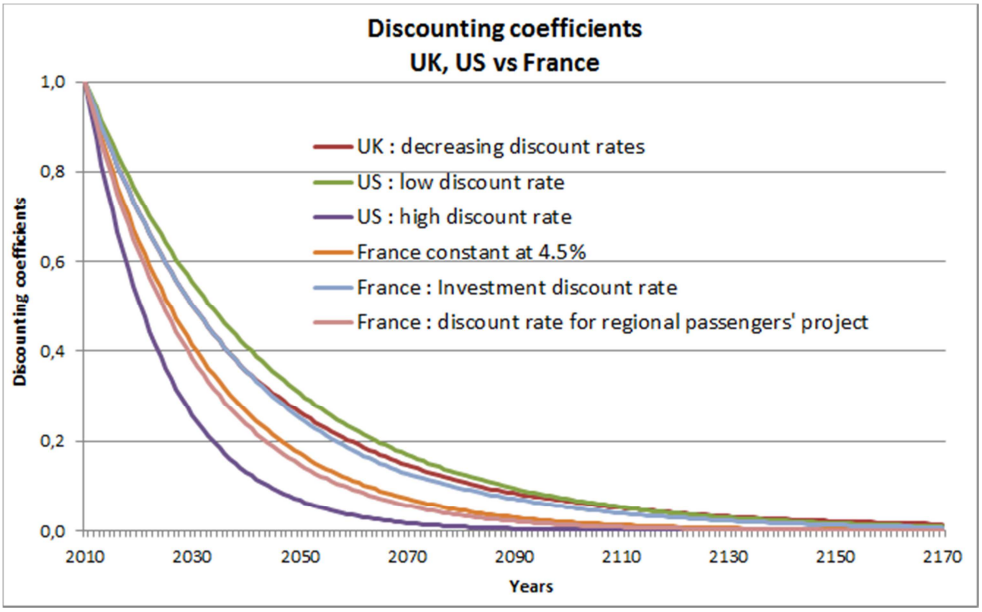
We recall that the US approach is with two discounting rates: low at 3% and high at 7%. The UK approach is with declining rates following terms (3.5% for 0 to 30 years, 3.0% for 31 to 75 years, 2.5% for 76-125 years etc.). The French approach with a fixed discounting rate is to apply the discounting rate at 4.5%. The French approach with discounting system is to apply different discounting rates following beta values for different flows of a project. For our regional project, we distinguish three discounting rates: one is for investment, one for CO2 and one for all other monetary flows.

The discounting rates are obtained as follows:

	Betas	Discounting rates	
		2010-2069	2070 and +
Risk free discount rate α		2,5%	1,5%
Risk premium μ		2,0%	3,0%
β for CO2	1,0	4,5%	4,5%
β for Investment	0,5	3,5%	3,0%
β for regional passenger traffic	1,2	4,9%	5,1%

Sources: France Stratégie following Quinet Report

These different discounting rates give the following discounting coefficients in chart:



Sources: France Stratégie

Concerning the project to which we apply the different discounting rates, the construction works start in 2020. The operation will start in 2024. We dispose of flows in 2010 constant € price from 2020 to 2170. The flows to be discounted are CAPEX, OPEX, revenue, CO2, and other environmental effects. We discount these flows at the year 2010. The CO2 value per ton is 100 €2010 in 2030 and grows as the discounting rate from 2031. The following table presents the results:

	NPV in M€2010				
		US		France	
	UK	Low	High	at 4.5%	Discounting system
Total from 2020 to 2170	314,7	365,2	-76,6	60,6	-51,4
NPV from 2020 to 2069	213,2	264,7	-21,4	95,8	13,2
NPV from 2070 to 2170	101,5	100,4	-55,2	-35,2	-64,6

Sources: France Stratégie

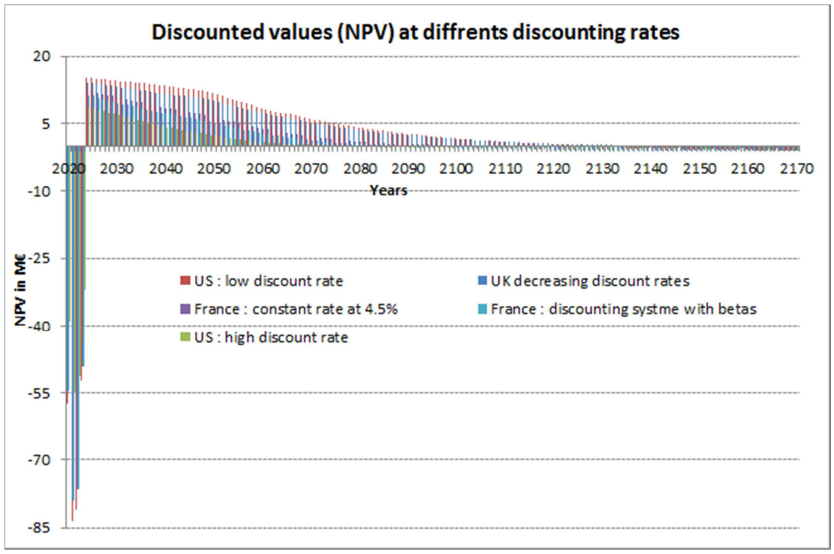
From these results, the total NPV

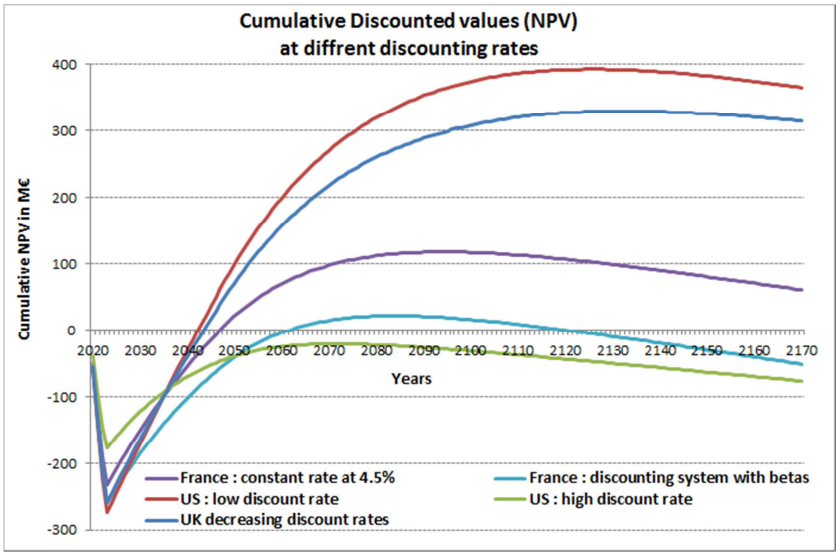
- are positive in three discounting situations: UK declining discounting rates, US low discounting rate, French fixed discount rate à 4.5%

- and negative in two discounting situations: French discounting system and US high discount rate

If the project choice is based on positive NPV, this project would be chosen in three situations and rejected in two situations.

The following charts present the NPV and the cumulative NPV of the results:





The cumulative chart shows that the cumulative NPV at US high discounting rate is never positive at any year from 2020 to 2170.

Conclusion remarks

From three different practices in the US, in the UK and in France, we see three approaches on discount rates: a vision of the fixed discount rate over time (the case of the US), a social vision of risk-free rates declining over time (the case of United Kingdom) and a vision of the discount system incorporating project-specific risk premiums (the case of France).

The application to a real project with the different discounting principles gives a very different contrast results. The same project would be promoted or rejected following the discounting principles. This subject is one of the discussions for the conference of 29 March 2017.

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