Chicago Journal of International Law

Volume 13 | Number 2 Article 13

1-1-2013

The Debate on Discounting: Reconciling Positivists and Ethicists

Christian Gollier

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Christian Gollier*

Abstract

Using a simple arbitrage argument, positivists claim that the interest rate provides the right basis to fix the discount rate to evaluate green investment projects. The real interest rate observed in the US during the twentieth century was around 1 percent. On the other hand, ethicists estimate the discount rate using the marginal rate of substitution between current and future consumption. From classical estimations of intertemporal inequality aversion and prudence, assuming a 2 percent growth rate of consumption, they recommend a discount rate of around 3.5 percent. Ethicists are therefore less prone to investing for the future than positivists. I provide two roads to reconcile the two approaches. First, I claim that the positivist approach is correct if green investment projects are financed by a reallocation of resources from productive capital in the economy, whereas ethicists are correct if the projects are financed by a reduction in current consumption. Second, I claim that ethicists should use a rate between 1 percent and 2 percent to discount sure benefits that occur in the distant future to take the uncertainty surrounding the future prosperity of the economy into account. Finally, a risk premium should be added to the discount rate that is proportional to the socioeconomic beta of the investment project.

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* Professor of Economics, Toulouse School of Economics. I thank the conference participants at The University of Chicago for providing many insightful comments on an earlier version of this paper. This research received funding from the European Research Council under the European Community's Seventh Framework Programme (FP7/2007–2013) Grant Agreement No. 230589. This project was also supported by the partners of the Chair "Sustainable Finance and Responsible Investment," and the French reinsurance company SCOR, which funded the Chair "Risk Markets and Value Creation" at the Industrial Economic Institute (IDEI).

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I. INTRODUCTION

In their recent book, *Climate Change Justice*,[1] Eric A. Posner and David Weisbach argued that issues related to distributional justice should not prevent us from pushing for effective policies to fight climate change.[2] They suggested that climate change agreements that are aimed at solving all of the world's ills and, in particular, at redistributing wealth across nations, are doomed to fail.[3] One particularly important issue is the problem of intergenerational justice, which is associated with the discount rate. In Chapter 7 of *Climate Change Justice*, Posner and Weisbach presented the two classical schools of thought for the determination of the discount rate: ethicist and positivist.[4] The "ethicist position" attempts to reason from basic principles about what the discount rate should be. One of these principles is a preference for the reduction of inequalities among successive generations. In contrast, the "positivist position" uses the standard arbitrage argument to claim that the discount rate should equal the interest rate observed in markets.[5] There is no doubt that Posner and Weisbach are inclined to support the positivist approach: "The positivists are correct that choosing any project that has a lower rate of return than the market rate of return throws away resources."[6]

In principle, if markets are frictionless and complete, the competitive allocation of resources is efficient, and competitive prices provide the right signals to agents to decentralize this allocation. Applied to credit markets, this means that the allocation of consumption and wealth across time is efficient, and that the interest rate should be used to discount cash flows. In particular, as

1 Eric A. Posner and David Weisbach, *Climate Change Justice* (Princeton 2010).

2 See id at 4–5, 96–98.

3 Id.

4 Id at 149–58.

5 Posner and Weisbach, *Climate Change Justice* at 150–53 (cited in note 1).

6 Id at 159.

explained by Posner and Weisbach, the intertemporal rate of marginal substitution (IRMS) of consumption today and tomorrow is equalized at equilibrium to the real rate of return of capital, that is, to the interest rate.[7] In other words, transferring consumption to the future by investing in capital has no impact on intertemporal welfare at the margin. In this context, Posner and Weisbach are perfectly right to claim that sacrificing current consumption to invest in projects that have a return smaller than the interest rate reduces intertemporal welfare and throws away resources.

However, we know that credit markets do not work particularly well. The recent subprime crisis illustrates the various agency problems that make these markets deeply inefficient. Moreover, recent research in behavioral economics tends to demonstrate that human beings may have difficulty behaving rationally relative to their consumption planning over their lifetime.[8] Last but not least, credit markets are obviously incomplete, in the sense that some mutually profitable credit contracts are not implemented at equilibrium. In particular, because they are still to be born, future generations are unable to write contingent contracts with current generations. These arguments imply that the market allocation of resources over time is inefficient, and that the competitive price of time does not provide the right signal to economic agents about saving and investment. This fact corresponds to the so-called "risk-free rate puzzle," which was first documented by Philippe Weil.[9] The puzzle states that the observed interest rate over the last century, which was approximately equal to 1 percent in real terms in the US, is much smaller than the IRMS, which is usually estimated around 4 percent in real terms. This puzzle tells us that positivists value the future much more than the ethicists, contrary to what is suggested by Posner and Weisbach. During the twentieth century, we accumulated much more capital than the ethicists would have recommended from their basic principles. This accumulation of physical, human, and intellectual capital indeed generated an extraordinarily large growth in developed countries, at the cost of very large consumption sacrifices from our poor past generations.

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7 See id at 144–47.

8 See, for example, David Laibson, *Golden Eggs and Hyperbolic Discounting*, 112 Q J Econ 443, 449–50, 454–60, 465 (1997) (explaining that higher immediate discount rates followed by lower long-term discount rates generate time inconsistencies by the decisionmaker, which is further exacerbated by instant access to credit); James K. Hammitt, *Positive v. Normative Justifications for Benefit-Cost Analysis* (unpublished paper, Harvard University, 2012), online at http://www.toulouse-justice-2011.fr/fullpapers/c3hammit.pdf (visited Oct 14, 2012) (providing an interesting discussion of the complexity of cost-benefit analysis under bounded rationality, incomplete markets, and the situation when losers cannot be compensated by winners).

9 See Philippe Weil, *The Equity Premium Puzzle and the Risk-Free Rate Puzzle*, 24 J Monetary Econ 401, 408–17 (1989).

Over the past decade, several of my colleagues contributed to reducing the gap between the positions of the positivists and of the ethicists. In my book, *Pricing the Planet's Future: The Economics of Discounting in an Uncertain World*,[10] I survey several of these attempts.[11] Most of these attempts are linked to the role of risk in the toolboxes of the two approaches. From the viewpoint of the positivists, because fighting climate change has uncertain cash flows, the risk-free interest rate is not the correct benchmark return to measure the opportunity cost of capital. Thus, adding a risk premium to the interest rate to determine the rate at which the net benefits of fighting climate change should be discounted is crucial. However, I do not know of any paper that provides estimations of the socioeconomic "beta" of investment projects that reduce CO_2 emissions. From the viewpoint of ethicists, recognizing the presence of huge long-term risks affecting economic growth tends to reduce their estimation of the IRMS. Prudent planners should ask for more sacrifices from current generations if future generations bear more risk.

Overall, I believe that a consensus is not out of reach between the ethicists and positivists, on the basis of a real discount rate for long-term investment projects that are safe around 1.5 percent. A risk premium should be added to this rate for projects whose future socioeconomic benefits are highly correlated to future GDP per capita. All rates used in the following sections should be interpreted as real rates.

In Section II, I will describe the positivist approach, switching to the ethicist approach in Section III. In Section IV, I compare the two approaches to evaluate safe projects and their consequences in terms of sacrifices to be made by current generations. Section V is devoted to the discount rate to be used to evaluate risky projects. Section VI concludes.

II. THE POSITIVIST APPROACH

Dimson, Marsh, and Staunton computed the annualized return on bonds and equities for different countries during the twentieth century.[12] Using extended data from the same authors from 1900–2006, the main facts are summarized in Table 1. In the US, the real return on Treasury Bills, which mature in one year or less and are probably the safest assets in the world, was

10 Christian Gollier, *Pricing the Planet's Future: The Economics of Discounting in an Uncertain World* (Princeton 2012).

11 See, for example, Martin L. Weitzman, *Subjective Expectations and Asset-Return Puzzles*, 97 Am Econ Rev 1102 (2007); Martin L. Weitzman, *Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate*, 36 J Envir Econ & Mgmt 201 (1998).

12 Elroy Dimson, Paul Marsh, and Mike Staunton, *Triumph of the Optimists: 101 Years of Global Investment Returns* (Princeton 2002).

around 1 percent. On the other hand, ten-year Treasury bonds delivered an average real return of 1.9 percent, and equities delivered one of 6.6 percent. The real return of these three asset classes varied significantly across different countries during the period of the study. In particular, the real return of fixed income assets was negative in some countries, including Japan, France, and Italy, where World Wars occurred.[13] Observe also that the equity premium varies across countries within the range of 3 percent to 7 percent. The same exercise was also repeated over the shorter time period of 1971–2006. It is notable that the safe return on government bonds was much larger during this period than over the century as a whole, whereas the return on equities remained stable. A possible explanation for this is the successful fight against inflation by central banks in recent years, a move that markets took time to understand before updating their beliefs.

	Government Bills (maturity <1 year)		Government Bonds (maturity=10 years)		Equity	
	1900–2006	1971–2006	1900–2006	1971–2006	1900–2006	1971–2006
Australia	0.6%	2.5%	1.3%	2.8%	7.8%	6.3%
Canada	1.6%	2.7%	2.0%	4.5%	6.3%	5.8%
Denmark	2.3%	3.5%	3.0%	7.0%	5.4%	9.0%
France	2.9%	1.2%	0.3%	6.6%	3.7%	7.8%
Italy	3.8%	0.3%	1.8%	2.8%	2.6%	3.0%
Japan	2.0%	0.4%	1.3%	3.9%	4.5%	5.0%
Netherlands	0.7%	1.8%	1.3%	3.9%	5.4%	8.5%
United Kingdom	1.0%	1.9%	1.3%	3.9%	5.6%	7.1%
Sweden	1.9%	2.4%	2.4%	4.2%	7.9%	11.0%
Switzerland	0.8%	0.4%	2.1%	2.8%	5.3%	6.1%
US	1.0%	1.3%	1.9%	4.0%	6.6%	6.6%

Table 1: Real returns of financial assets[14]

Note that we do not observe the return of assets whose risk-free cash flows mature in time horizons exceeding thirty years. The positivist approach fails to provide any clear answer to the determination of the arbitrage-free discount rate for those horizons. The arbitrage argument entails a reinvestment

13 Id.

14 Id.

risk in that case. If we consider a project yielding risk-free cash flows in sixty years, the natural arbitrage strategy would be to invest in a bond yielding a risk-free return in thirty years, and then to reinvest in another thirty-year bond at that time. The problem is that we do not know today what the risk-free rate will be in thirty years. How should we treat this source of uncertainty related to the opportunity cost of capital? Posner and Weisbach follow a proposal by Martin Weitzman[15] to answer this question.[16] They claim that when the interest rate r is uncertain, a risk-free investment project entailing a sure cost I_0 and a sure benefit F_t in t years should be implemented if and only if its expected net present value (NPV) is positive, for example, if and only if $-I_0 + E[F_t e^{-rt}]$ is positive.[17] Because the present value $F_t e^{-rt}$ is decreasing and convex to the discount rate r, this is equivalent to using a decision rule based on a "certainty equivalent" discount rate R_t that is smaller than the expected interest rate.[18] I have shown that this argument to reduce the discount rate has no scientific basis,[19] because even a risk-neutral investor would not use the expected NPV criterion to evaluate risk-free projects when the interest rate is random. For example, such an investor could use the alternative expected net future value (NFV) criterion in such a way that a project would be said to be desirable if the expectation of its NFV, $-E[I_0 e^{rt} + F_t]$, is positive.[20] This would yield the opposite policy recommendation to raise the certainty equivalent discount rate under uncertainty. The bottom line is that even positivists need to rely on ethical principles when prices are not observable or when markets are incomplete. I will come back to this point in the next section.

III. THE ETHICIST APPROACH

The Ramsey rule tells us that the intensity of this wealth effect is equal to the product of the growth rate g of consumption by the degree, y, of relative inequality aversion. This rule can easily be derived from the social welfare function (SWF) described below. Consider a small sure investment project that costs I_0 per capita today and that generates a sure benefit F_t at date t. Given that

15 Weitzman, 36 J Envir Econ & Mgmt at 205–07 (cited in note 11) (arguing that the lowest possible interest rate should be used for discounting the far-distant future part of any investment project).

16 Posner and Weisbach, *Climate Change Justice* at 152 (cited in note 1).

17 Id.

18 More precisely, we can define the certainty equivalent discount rate R_t in such a way that it is easy to check from this definition that R_t is a decreasing function of t.

19 Christian Gollier, *Maximizing the Expected Net Future Value as an Alternative Strategy to Gamma Discounting*, 1 Fin Rsrch Let 85, 86–88 (2004).

20 Notice that the NPV and NFV criteria are strictly equivalent under certainty.

consumption per capita is c_0 and c_t respectively at date 0 and t, investing in the project raises the SWF if and only if

$$u(c_0 - I_0) + u(c_t + F_t) \geq u(c_0) + u(c_t), \tag{1}$$

Where $u(c)$ is the utility generated by consuming c. Because the cash flows of the investment are small, the above inequality holds if and only if

$$-I_0 u'(c_0) + F_t u'(c_t) \geq 0. \tag{2}$$

This inequality can be rewritten as an NPV condition, $-I_0 + F_t e^{-rt}$, where the discount rate would be defined as follows:

$$e^{-rt} = \frac{u'(c_t)}{u'(c_0)}. \tag{3}$$

The right-hand side of this equality is the IRMS. Now, suppose that consumption grows at a constant rate g, so that $c_t = c_0 e^{gt}$. Suppose also that the elasticity of marginal utility to changes in consumption is a constant γ, so that $u'(c) = c^{-\gamma}$. Introducing these conditions into equation (3) implies that

$$e^{-rt} = \frac{u'(c_t)}{u'(c_0)} = \frac{(c_0 e^{gt})^{-\gamma}}{c_0^{-\gamma}} = e^{-\gamma g t} \tag{4}$$

so that $r = \gamma g$, thereby proving the Ramsey rule.

Notice that parameter γ is ethical. I hereafter use $\gamma = 2$. This means that one is ready to sacrifice as much as $4 from the rich to increase consumption of the poor by $1, when the consumption of the rich is twice the consumption of the poor. If one assumes that the average growth rate of consumption in the future will be close to the one that has been observed in the Western World since the Industrial Revolution, one should use $g = 2\%$. This implies a socially efficient discount rate of around $2 \times 2\% = 4\%$. Of course, this estimation is sensitive to the selection of the parameters present in the Ramsey rule. The lowest rate existing in the literature was obtained by Stern, who took $g = 1.3\%$ and $\gamma = 1$, yielding a discount rate of 1.3 percent.[21]

In reality, the Ramsey rule is useless because we do not know what the growth rate of consumption will be in the future. Estimating the growth rate of

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21 In fact, Stern uses 1.4 percent because he also takes into account of a 0.1 percent probability per year that humanity will disappear. Nicholas Stern, *The Economics of Climate Change: The Stern Review* 181–89, 662–65 (Cambridge 2007).

consumption just for the coming year is already a difficult task. Any estimate of growth for the next decade is potentially subject to very large errors. Over a century, estimation errors could be enormous. When the growth rate of consumption is unknown, the intensity of the wealth effect cannot be estimated, and the Ramsey rule is unable to produce a precise prescription for the choice of discount rate. Uncertainty over how wealthy the future will be casts at least some doubt on the relevance of the wealth effect to justify the use of a large discount rate.

How should the Ramsey rule be adapted in an uncertain world? Determining the optimal level of savings requires an estimate of the future utility gain of this wealth transfer, in a context in which little is known about future incomes. This problem is at the core of the question of what should be done for the future. It is commonly accepted that individuals are ready to sacrifice more in the present, to be used in the future, if the future becomes more uncertain. John Maynard Keynes was the first to articulate this idea by pointing out the precautionary motive for saving.[22] What is desirable at the individual level is also desirable at the collective one. A society that wants to reinforce the incentive to invest for the future should select a smaller discount rate to evaluate the set of all possible safe investment projects. Thus, ethicists should reduce their estimation of the discount rate in the face of uncertain economic growth.

What is the intensity of this precautionary effect? If it is assumed that the growth rate of consumption follows a random walk,[23] I have shown that the discount rate should be uniformly reduced by $0.5y(1+y)\sigma^2$, where σ is the volatility of the growth rate of consumption.[24] The observed volatility of economic growth in the twentieth century in Western economies was around 4 percent. This yields a precautionary effect that reduces the discount rate by 0.48 percent. Combining the wealth effect and the precautionary effect yields a discount rate of 3.5 percent.

However, various authors have argued that modelling uncertainty by a random walk for the growth rate of consumption may be reasonable for short-term horizons, but might vastly underestimate the long term uncertainty that our planet faces.[25] The history of the western world before the Industrial Revolution

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22 John M. Keynes, 1 *A Treatise on Money* 30–32 (Macmillan 1971).

23 See F. Russell Denton, *Random Walks, Non-Cooperative Games, and the Complex Mathematics of Patent Pricing*, 55 Rutgers L Rev 1175, 1200 (2003) (describing the random walk analysis in terms of an object moving at random in any direction after each step); Gollier, *Pricing the Planet's Future* at 49–50 (cited in note 10) (explaining that growth rates that follow a random walk mean that past growth does not give any information about future growth).

24 Christian Gollier, *Time Horizon and the Discount Rate*, 107 J Econ Theory 463, 466–72 (2002).

25 See, for example, Gollier, *Pricing the Planet's Future* at 61–73 (cited in note 10); Weitzman, *Subjective Expectations and Asset-Return Puzzles* at 1121–22 (cited in note 11).

is full of significant economic slumps, such as those occurring after the collapse of the Roman Empire in the fifth century, or the Black Death epidemic in the mid-fourteenth century. Some argue that the effects of improvements in information technology have yet to be realized, and that the world is entering a period of more rapid growth. By contrast, those who emphasize the effects of natural resource scarcity, or the inability of financial markets to allocate capital efficiently, predict lower growth rates in the future. Some even suggest a negative GDP per capita growth, owing to a deterioration of the environment, population growth, and a progressive deceleration of the productivity of capital and labor. The implication of this last position is that the wealth effect on the discount rate is negative rather than positive, as supposed by most experts. Under these plausible beliefs, the future is poorer than the present so we should make more sacrifices today to improve the future. This short discussion tells us that our civilization faces uncertain future shocks that are likely to be persistent. When shocks exhibit some degree of persistence, assuming a random walk for the consumption growth rate underestimates the uncertainty affecting the level of consumption enjoyed by future generations. Thus, this underestimates the precautionary effect affecting the discount rate to be used for those very long maturities.

I have modelled economic growth by considering various stochastic processes with persistent shocks:[26] mean reversion processes, Markov regime-switches, and Brownian processes with parametric uncertainty. These models support a decreasing term structure for the discount rate, with a short-term rate around 3.5 percent, and a discount rate for time horizons exceeding one or two centuries between 1 percent and 2 percent. This decreasing structure biases the evaluation of safe investment projects in favor of those that generate benefits in the distant future.

In conclusion, ethicists base their evaluation of the discount rate on collective preferences characterized by inequality aversion and prudence. Inequality aversion justifies using a discount rate of around 4 percent per year. The precautionary effect justifies reducing this rate by around 0.5 percent for short maturities and by as much as 3 percent for much longer maturities.

IV. THE RISK-FREE RATE PUZZLE

Weil was the first to observe that the positivist and the ethicist positions are difficult to reconcile, in the sense that the observed interest rates are much smaller than the IRMS.[27] Indeed, the real interest rate was between 1 percent and

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26 Christian Gollier, *Discounting with Fat-tailed Economic Growth*, 37 J Risk & Uncertainty 171 (2008).

27 Weil, *The Equity Premium Puzzle* at 408–12 (cited in note 9).

2 percent, whereas the IRMS for time horizons treated by financial markets (less than thirty years) was estimated to be above 3.5 percent. In other words, economists have a hard time explaining why people sacrificed much of their past consumption to accumulate capital in a context of low interest rates and bright economic prospects. From the ethicists' viewpoint, this intertemporal allocation of consumption over the last century or so was vastly inefficient, because it requires too much sacrifice from poorer old generations for the benefit of the currently rich. For them, this could be justified only by the presence of a sequence of extremely profitable short-term investment projects with a sure return of at least 3.5 percent. This position is contradicted by the positivists' observation that the interest rate, which reflects the rate of return for safe capital, has been much smaller, around 1 percent or 2 percent. Ethicists would postulate that one has invested too much in the past, and that one should abstain from investing in all projects with returns between 2 percent and 3.5 percent. This sheds some light on the debate about the apparent short-termism of financial markets. In fact, financial markets have been more long-termist than one would have liked from the viewpoint of intergenerational welfare.

It is interesting to observe the reversal of attitude toward the discount rate of the two approaches. Because positivists recommend a lower discount rate than ethicists, the former are more favorable to sustainable development than the latter, at least when evaluating projects maturing in less than thirty years. Who is correct? To answer this question, consider an investment project with a relatively short maturity rate that exhibits a sure 3 percent real rate of return. Under the positivist approach, one should implement the project, whereas ethicists would go against its implementation. My position on this is contingent on the method in which the project is funded. If it is financed by a reallocation of productive capital from a sector producing a return of 2 percent, there is no doubt that the project should be implemented. If it is financed by a reduction in the consumption of current generations, I would strongly reject this proposal.[28]

However, this discussion is not really relevant for climate change, because our actions to fight it will mature only in the distant future for which there is no corresponding risk-free asset traded on the markets. As noted before, positivists are not in a situation to make a recommendation for the rate at which long-term benefits should be discounted. On their side, ethicists recommend a discount rate that is smaller than 3.5 percent, and that is close to 1 percent to 2 percent, as

28 Lawrence H. Goulder and Roberton C. Williams III, *The Choice of Discount Rate for Climate Change Policy Evaluation* *10–11 (National Bureau of Economic Research Working Paper 18301, Aug 2012), online at http://www.nber.org/papers/w18301.pdf (visited Oct 14, 2012) (suggesting that transferring resources to the future by consuming less now might not always lead to the most efficient maximization of intertemporal social welfare).

recommended by the positivists for short horizons. It is unclear whether anything more than that can be said to compare the two positions, given the non-applicability of the arbitrage argument used by the positivists in this context.

V. Discounting Risky Projects

The Capital Asset Pricing Model (CAPM) predicts that the risk premium observed on financial markets for a specific risk profile should be proportional to its financial beta (β), which measures the expected percentage increase in the value of the project when the market value of the S&P 500 increases by 1 percent. In particular, marginal projects whose risks can be diversified away in individual portfolios should not get any risk premium.[29] They are actuarially priced. That is, they should be implemented as soon as the discounted value—with a rate of 2 percent of their expected cash flows—is non-negative. A project with a risk profile β should be discounted at a rate equaling 2% + $\beta \times$ 4.6%.

The ethicist approach is based on estimating the impact of the additional risk generated by the project on the well-being of future generations. Adding risk to consumption is bad for future generations because they are risk-averse. This risk aversion comes from the concavity of the utility function, which implies that a given reduction in consumption has a larger impact on utility than its equivalent increase. Consider, for example, an investment project whose risk profile is identical to the uncertainty affecting aggregate consumption growth: when the risk profile increases by 1 percent, so does the socioeconomic benefit of the project. It is easy to verify that such a marginal investment project increases intergenerational welfare if and only if the net present value of its flow of expected benefits is positive, where the discount rate is adapted to the riskiness of the project by adding a risk premium to the risk-free rate examined in Section III of this paper.[30] This risk premium is equal to $\gamma\sigma^2$, where σ is the volatility of the growth rate of consumption. Using $\sigma = 4\%$ as before, this yields a risk premium associated with the macroeconomic risk at around 0.32 percent. Using a risk-free discount rate of 3.5 percent, this computation supports a discount rate around 3.82 percent. The Consumption-based Capital Asset Pricing Model (CCAPM) extends this methodology for other risk profiles. Under the CCAPM, the risk profile of an investment is summarized by its socioeconomic beta (β^{se}), which measures the expected percentage increase in the socioeconomic value of the project when aggregate consumption increases by 1 percent. The socially efficient discount rate to be used for a project with a

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29 Kenneth J. Arrow and Robert C. Lind, *Uncertainty and the Evaluation of Public Investment Decisions*, 60 Am Econ Rev 364, 372 (1970).

30 Gollier, *Pricing the Planet's Future* at 185–201 (cited in note 10).

risk profile of β^{se} is equal to 3.5% + β^{se} × 0.32%.[31] In particular, a risky project whose benefits are not correlated to aggregate consumption should be discounted at the risk-free rate discussed in Section III of this Article.

In order to compare the two positions, let us see how an ethicist would evaluate a project whose risk profile is similar to the diversified portfolio of US equities. The socioeconomic beta of the S&P 500 is estimated at β^{se} = 1.72. Thus, ethicists should use a discount rate of 3.5% + 1.72 × 0.32% = 4.05%. This is in contrast to the 6.6 percent proposed by positivists to discount this project. Because the equity premium of 4.6 percent observed during the twentieth century is much smaller than the equity premium of 0.55 percent estimated by the ethicists, we obtain a new reversal of the two positions with respect to the valuation of the future: ethicists are more investment-prone than positivists when projects are risky. This phenomenon corresponds to the well-known "equity premium puzzle" first discovered by Rajnish Mehra and Edward Prescott.[32] During the twentieth century, markets compensated risk taking much more than was socially efficient. Shareholding companies that undertook risky projects incurred much larger costs of capital than safer firms. This implies that much less risk was undertaken during the period than was desirable from the viewpoint of intergenerational welfare.

Similarly, these observations hold for risky projects with relatively short maturities. For larger maturities, both the risk-free discount rate and the macroeconomic risk premium should be adapted. When the macroeconomic risk is subject to persistent shocks, the term structure of the risk premium will increase. In *Pricing the Planet's Future*, I recommended a macroeconomic risk premium in the range of 1.5 percent and 3 percent for long horizons.[33]

Another important task is thus to determine the socioeconomic beta of investment projects, whose main benefits come from reduced CO_2 emissions. Estimating this parameter from market data is problematic, because these benefits have not materialized yet. Because this will remain the case for many years, we must thus again rely on a model. Some believe that the benefits from reducing emissions will be the largest when economic growth is also large—that is, when a large number of accumulated assets are under the peril of climate change. Others believe the opposite. For them, the benefits from reducing emissions will be the largest in scenarios where our civilization reverts back to the Stone Age; the marginal utility of these benefits will be large when many people will not starve thanks to these past efforts. The former should use a large

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31 Id.

32 Rajnish Mehra and Edward C. Prescott, *The Equity Premium: A Puzzle*, 15 J Monetary Econ 145 (1985).

33 Gollier, *Pricing the Planet's Future* at 196–99 (cited in note 10).

discount rate for climate change (because of the large beta), whereas the latter should use a much smaller discount rate for climate change that is potentially smaller than the interest rate (because of the negative beta).

VI. CONCLUSION

Do we do enough for the future? If we consider the near future, we can answer this question by examining the interest rate level in financial markets, which represents the opportunity cost of capital. Positivists are perfectly right to oppose transferring resources from productive capital in the economy to green investment projects with socioeconomic returns less than the interest rate. That would be bad news for future generations. On the other hand, ethicists are concerned with the problem of whether the level of the interest rate is compatible with intertemporal welfare. There are indeed many reasons to believe that financial markets do not allocate resources efficiently through time. This implies that there may exist at equilibrium unexploited transfers of consumption that increase intertemporal welfare. Paradoxically, the so-called risk-free rate puzzle tells us that ethicists are less prone to sacrifices for the future than positivists. The Ramsey rule—which is the scientific basis used by ethicists—tells us that the sacrifices made by poor past generations in terms of accumulating capital were much too large compared to what would be desirable in terms of intertemporal justice. Ethicists would recommend using a discount rate *larger* than the interest rate observed on markets.

The interest rate observed in financial markets is the rate of return for risk-free capital. Any action that diverts some of this productive capital into a safe investment project, whose return is smaller than the interest rate, destroys wealth. If asked, future generations would reject this action. This arbitrage argument provides a strong argument for using the interest rate as the rate to discount risk-free investment projects.

If we are interested in very short-time horizons, bills are the relevant asset class, and a discount rate not larger than 1 percent is relevant. Of course, this rate should be flexible along the business cycle to take into account the cyclicity of the opportunity cost of capital. If we are interested in risk-free cash flows maturing in ten years, US bonds maturing at the same date are the relevant benchmark asset to perform the arbitrage argument. A real discount rate around 2 percent is relevant in that case.

The point here is that positivists do not provide a satisfying answer with regards to choosing a discount rate that corresponds to time horizons expressed in decades and centuries, which are outside the scope of liquid financial markets.

To sum up, we see that the positivist position, which implies a discount rate between 1 percent and 2 percent, depending upon the maturity and the position in the business cycle, is limited by the problem of incomplete markets.

We simply do not observe traded assets whose risk and time profiles fit those of climate change. This implies that positivists need to complement their analysis with ethical principles and economic models.

Ethicists consider another road to estimate the socially efficient discount rate. Remember that the positivists' arbitrage argument relies on the assumption that the investment project under scrutiny is financed through a reallocation of productive capital. Under the positivist approach, no additional sacrifice is requested on the side of current generations, because this reallocation is neutral to their welfare. Thus, only future generations are impacted by this reallocation. The ethicist approach is based on the alternative assumption that the new project entails a reallocation of consumption through time, because the initial implementation cost is financed by a corresponding reduction in current consumption. Ethicists must thus compare the benefit for the future generation to the cost borne by the current one, an exercise that involves interpersonal comparisons of welfare. Their estimation of the discount rate is based on the measurement of the IRMS between current and future consumption.

Together with Posner, Weisbach, and most ethicists, I reject weighing utility changes differently for people of different generations. In other words, I give no preference to the present. Ethicists value a transfer of consumption by its impact on a SWF. With them, I assume that this SWF amounts to the undiscounted sum of the flow of utility by the different generations. There are several ways to interpret the SWF. The simplest approach assumes that the current generation is altruistic and values the flow of future consumption as its own consumption. Under that interpretation, the characteristics of the utility function are the preferences of the current generation with respect to intertemporal inequality. This interpretation is, of course, particularly relevant for short time horizons. An alternative interpretation of the SWF is that it represents our collective attitude toward the distribution of well-being across generations. The concavity of the utility function expresses the aversion to intergenerational inequality in that case. This interpretation of the SWF is applicable for long time horizons. In any case, the concavity expresses an aversion to consumption inequality.

Ethicists using the SWF described above usually recommend a positive discount rate on the basis of the following wealth argument: in a growing economy, future generations will be wealthier than we are. Because marginal utility of wealth is decreasing, an additional unit of consumption in the future has a smaller impact on the SWF than an additional unit of consumption today. Thus, one should depreciate changes in consumption that occur later in time. The positive discount rate expresses this wealth effect. It is the minimum rate of return of a safe investment project that compensates for the fact that implementing it transfers consumption from the current poor to the future rich.

In other words, it accounts for the increased intertemporal inequality that the project generates.

Most real collective projects are not safe, and indeed, many of them are very risky. This is particularly the case for those yielding cash flows in the distant future. For example, the size of the damage associated with climate change is vastly uncertain. How should this affect the way in which we discount the reduction of these damages obtained from our green investments? In a highly uncertain future, how do we value research and development yielding uncertain distant benefits and costs, as is the case for genetically manipulated organisms or space exploration? In a less abstract fashion, how do we compare the merits of various investment projects that differ not only in their maturities, but also in their degrees of riskiness? For example, should we invest in fighting malaria, which has immediate and nearly certain benefits, or in new education and transportation infrastructures in developing countries, which have more distant and uncertain benefits?

The positivists and the ethicists have different strategies to answer these questions. Let us first examine the solution provided by the positivists for relatively short time horizons. Extending the arbitrage argument presented in Section II to risky projects, one should discount the flow of future expected benefit at the market rate of return of an asset whose risk profile is identical to one of the investment projects under evaluation. Those assets may not be easy to identify. Let us consider a simple application of this arbitrage argument by considering a project whose risk profile is identical to that of a diversified portfolio of US stocks, for example, the S&P 500. If we rely on Table 1, the expected benefits of this risky project should be discounted at a rate around 6.6 percent. This discount rate contains the risk-free interest rate of around 2 percent, and a risk premium of 4.6 percent. This gives an order of magnitude of the impact of the riskiness of the project itself, on the rate at which it should be discounted when using the positivist approach.

The problem of incomplete and inefficient financial markets is particularly acute when considering longer time horizons. In particular, future generations cannot trade on these markets, thereby raising more concerns about the efficiency of the intertemporal allocation of resources. Moreover, one does not observe liquid and safe assets with maturities longer than thirty years. This implies that the positivist arbitrage argument cannot be used to determine the efficient rate at which long-term investment projects should be discounted. The determination of the efficient long-term discount rate should then rely on the kind of models used by ethicists. The large uncertainties associated with the well-being of distant generations justify using a decreasing term structure of the discount rate. I recommend using a real discount rate between 1 percent and 2 percent for time horizons exceeding a century. This shows that we are not far from reconciling ethicists' and positivists' positions.

Finally, it is crucial to clarify that we are talking about the discount rate for safe projects. Because green investment projects have highly uncertain distant socioeconomic benefits, a risk premium should be added to the discount rate. This risk premium should be proportional to the socioeconomic beta of these green projects. It is a shame that the economic literature on climate change has not yet addressed this question.