Discounting with first-order inequality aversion

CHRISTIAN GOLLIER
Toulouse School of Economics

KARINE VAN DER STRAETEN
Toulouse School of Economics

JIAKUN ZHENG
Aix Marseille Univ, CNRS, AMSE, Centrale Méditerranée

In a new experimental design, we document much less willingness to trade more inequality for more prosperity than to trade less prosperity for less inequality. This is possible in the utilitarian framework only under first-order inequality aversion. Based on this observation, we explore a new discounting model with overlapping generations in which we disentangle risk aversion from inequality aversion, the latter containing an upward jump in marginal utility at the lower generational certainty-equivalent consumption level. We generate a CCAPM-like discounting system that is calibrated using our survey. In spite of the large observed first-order inequality aversion among our respondents, it generates a risk-free discount rate around 2%. We highlight the impact of first-order inequality aversion on the shape and level of the term structures of risk-adjusted discount rates.

KEYWORDS. Rawls, Ramsey rule, discount rate, decreasing term structure

JEL CODES. D81, G11, Q28.

Christian Gollier: christian.gollier@tse-fr.eu
Karine van der Straeten: karine.van-der-straeten@tse-fr.eu
Jiakun Zheng: jiakun.zheng@centrale-med.fr

1. Introduction

In a growing economy, the efficient discount rate is the minimum internal rate of return of a safe investment that is required to compensate for the fact that investing for the future raises intertemporal or intergenerational inequalities. In the utilitarian framework, this idea is translated into mathematical terms by the Ramsey rule. It states that the efficient discount rate is equal to the product of the degree of inequality aversion by the growth rate of consumption.[1] There is no consensus on the intensity of inequality aversion that should be used to calibrate the Ramsey rule.

The standard experimental approach to estimate the intensity of inequality aversion is based on a "leaky bucket" design proposed by Okun (1975). Some money is transferred from a high-income person to another lower-income person, but a certain fraction of this money is lost in the process. The respondents are requested to determine the minimum amount to be received by the lower-income person per dollar taken from the rich to make this deal socially desirable. The smaller this amount, the larger the inequality aversion. For example, if the rich is 3 times wealthier than the poor, a minimum amount of 33.3 cents for the poor per dollar taken from the rich corresponds to a relative inequality aversion of 1, whereas a minimum amount of 3.7 cents corresponds to a relative inequality aversion of 3. In short, the leaky bucket experiment measures the willingness to trade less prosperity for less inequality. Using this procedure, Amiel and Cowell (1999) obtained an estimated median relative inequality aversion between 0.1 and 0.2. This extremely low estimate compared to the experts' beliefs in economics has been confirmed by Pirttila and Uusitalo (2010), with a median estimate below 0.5. Recognizing this evidence would force economists to revise their estimation of the efficient discount rate downwards, potentially down to one-tenth of the expected growth rate of incomes.

This paper starts from the observation that, in a growing economy, investing for the future is akin trading *more* intergenerational inequality for *more* prosperity (induced by the investment's return). This is at odd with the leaky bucket experiment, in which respondents trade less inequality for less prosperity. Our hypothesis in this paper is that people exhibit more inequality aversion when considering policies that make the poor poorer than when considering policies that make the poor wealthier. This hypothesis is referred to in this paper as First-Order Inequality Aversion (FOIA). This is in the spirit of Rawls (1971). The rawlsian difference principle states that inequalities are to be arranged so that they are to the greatest benefit of the least advantaged. Reducing the income of the poorest people is an absolute taboo that should be avoided at any cost. In an intergenerational context, it implies an infinite discount rate whenever the economy is growing. Arrow criticized Rawls on the basis of this outcome of the difference principle applied to an intergenerational framework (Arrow, 1973). Rawls reacted by suggesting that the difference principle is not applicable to an intergenerational framework without some adjustments.

[1] We ignore here the morally problematic concept of a pure preference for the present when applied to interpersonal temporal transfers.

We explore the possibility that people are "partially rawlsian" by developing and testing the concept of FOIA, which is a smooth, first-order version of the difference principle. To test this hypothesis, we ask respondents of the leaky bucket experiment to also consider a symmetric "productive pipeline" experiment. Under this second experimental design, the respondents are requested to determine the maximum amount that could be sacrificed from the lower-income person per dollar obtained by the rich to make this deal socially desirable. Our FOIA hypothesis posits that the response from this productive pipeline design will be smaller than the response from the leaky bucket design.

We first show that the two questions should yield exactly the same answer in the utilitarian framework whenever the utility function is continuously differentiable at the income levels of the two individuals involved in the transfer. Thus, our hypothesis posits that this utility function has at least one concave kink. This is reminiscent of the concept of loss aversion in non-expected utility theory (Kahneman and Tversky, 1979). This kink in the utility function implies first-order risk aversion (Segal and Spivak, 1990). By symmetry, our hypothesis posits first-order inequality aversion. An extreme version of it occurs when marginal utility goes to infinity at the income level of the poorest individual, yielding the rawlsian maxmin criterion.

To empirically test our hypothesis, we conducted a survey experiment using a convenience sample from France. In the survey, respondents were asked both the leaky bucket question and the productive pipeline question, which we previously elaborated on, under the veil of ignorance (Rawls, 1971). Specifically, they were asked to imagine living in a society with two social classes—the rich and the poor—where the rich earn an annual after-tax income of €54,000 and the poor earn €18,000. Both the transfer from the rich to the poor in the leaky bucket question and the benefit to the rich from sacrificing the poor in the productive pipeline question is set at €1,000. Respondents were told they had an equal chance of belonging to either class. We also measure the respondents' degree of risk aversion by raising two questions involving lottery choices. To obtain a representative sample of the French population, we outsourced data collection to a French survey company called Bilendi.[2] Our initial sample consists of 3,010 French adults. Its key demographic characteristics–including gender, age, professional security contract (CSP), and region–are representative of the broader population.

As a preview of the results, we observed a significantly lower degree of inequality aversion in the leaky bucket question compared to the productive pipeline question, thereby confirming our FOIA hypothesis.[3] In the leaky bucket question, for people to accept a sacrifice of €1,000 from the rich, the average minimum gain required for the poor was €291.06, with a standard deviation of €342.55. In contrast, in the productive pipeline question, to produce a benefit of €1,000 for the rich, the maximum amount people are willing to sacrifice from the poor was only €64.75, with a standard deviation of €188.10. Perhaps surprisingly, in the leaky bucket question, 53.17% of our respondents accepted a redistribution policy that resulted in an efficiency loss of €900, implying an extremely high level of inequality aversion. This figure becomes even more pronounced in the productive pipeline question: 84.11% of the respondents were unwilling

[2]The survey company's website can be accessed here: https://www.bilendi.fr.

[3]We also conducted the same survey with a group of French economists and observed similar results, which are discussed in a companion paper.

to sacrifice the poor for €100 to grant the rich a benefit of €1,000. Assuming utilitarian behavior with constant relative inequality aversion, maximum likelihood estimation under log-normal distributions estimates the inequality aversion to be 4.33 when using only the responses from the productive pipeline design, which is twice that of 2.32 when using only the responses from the leaky bucket design.

These observations are interesting for two reasons. First, observe that they radically differ from those of Amiel and Cowell (1999) and Pirttila and Uusitalo (2010) who obtained much smaller estimations of inequality aversion in the leaky bucket experiment. Second, the important asymmetry in attitudes toward socially regressive and progressive policies confirms the necessity to revise the Ramsey model to include FOIA. This is the main objective of this paper.

Inequality aversion matters for efficient discounting only when those who fund some investments are not the ones who will benefit from them in the future. To address this aspect of the problem, we examine an Blanchard-Yaari overlapping generations model (Yaari, 1965, Blanchard, 1985). Namely, in each period, a constant proportion of people die and are replaced by an equivalent number of newborns. There is no inequality at any given date, but the brownian economic growth implies intergenerational inequalities. At each instant in time, people evaluate their remaining lifetime welfare by using the standard discounted utility model with constant relative risk aversion. Intergenerational welfare is defined as the sum of expected social utility of the flow of generational certainty-equivalent consumption levels, using a FOIA social utility function. Such a function exhibits CRRA with a kink at the consumption level of the poorest generation involved in the transfer of consumption. The individual and social preferences are estimated from the data generated from our survey. We analytically characterize the term structures of risk-adjusted discount rates in this framework. They generalize the standard pricing rules of Ramsey (1928) and, more generally, of the Consumption-based Capital Asset Pricing Model (CCAPM). We examine two pricing frameworks: one in which inequalities are measured ex ante, and the other in which they are measured ex post.

Our estimation of the FOIA social utility function using the two experiments yields a relative inequality aversion of $\gamma = 2.29$, but with a kink in this function at the lower generational consumption level. Namely, marginal utility is multiplied by $\eta = 9.74$ when consumption drops below that level. In other words, reducing the consumption of the poorest by 1 has the same impact on social welfare as an increase in that consumption by 9.74. The γ inequality aversion is within the range between 1 and 4 that has been traditionally used to calibrate the Ramsey rule. In the Stern Review (Stern, 2007) for example, a relative inequality aversion of 1 was used. But Dasgupta (2007) considered this choice as "deeply unsatisfactory", arguing that it means that inequalities do not matter much in most policy designs. He recommended using an aversion of 3 or 4. Drupp et al. (2018) has surveyed 173 academic experts in climate economics to elicit the elasticity of marginal utility, another name for the relative inequality aversion under the utilitarian framework. The mean relative inequality aversion is 1.35, but there is a large response heterogeneity, as expressed by a standard deviation of 0.85.

In spite of the relatively large first-order (η) and second-order (γ) inequality aversion that we derive from our survey, it turns out that our estimation of the efficient discount rates is close to those observed in financial markets. For example, we obtain short-term risk-free discount rates that are between 1.7% and 2.2%, with an almost flat term structure. The aggregate risk premium is estimated to be around 1.2%, with an increasing term structure. We show that the effect of first-order inequality aversion vanishes for long maturities.

2. A SURVEY EXPERIMENT

2.1 *Survey Design and Its Implementation*

The survey experiment uses a within-subject design. All participants completed two categories of tasks: individual risk tasks and social allocation tasks. The social allocation tasks included the leaky bucket and productive pipeline questions. The individual risk tasks included the corresponding risk-reducing and risk-taking questions that mirror the social allocation tasks. Both the order of task categories (individual versus social) and the order of questions within each category were randomized at the individual level.

In the social allocation tasks, we ask respondents to envision a world with two equally sized income classes: the rich and the poor. Moreover, following Rawls' veil of ignorance concept (Rawls, 1971), we instruct respondents to assume they have an equal chance of belonging to either class. The poor earn an after-tax income of €18,000, which roughly corresponds to the minimum yearly income in France, while the wealthy earn an after-tax income of €54,000. Thus, the rich earn three times more than the poor.

In the leaky bucket question, respondents face a list of ten binary choices: whether to implement a redistribution policy that transfers €1,000 from the rich to the poor, despite some efficiency loss, meaning the poor receive only a portion of the total transfer. Specifically, moving down the list, the amount of money that the poor can receive from the policy decreases from €1,000 to €100 in increments of 100. After completing these binary choices, respondents receive an open-ended question explicitly asking for the minimum amount the poor would need to receive for them to accept such a policy. Conversely, in the productive pipeline question, we assess respondents' willingness to accept a policy that grants a €1,000 benefit to the rich while imposing a cost on the poor. Similar to the leaky bucket question, respondents face a list of ten binary choices on whether to implement such a policy, with the cost to the poor increasing from €100 to €1,000 in increments of 100. After these questions, we ask respondents to specify the maximum loss to the poor they would accept for the policy to be implemented.

In the individual risk tasks, subjects face a reference lottery that pays either €18,000 or €54,000 with equal probability. In the risk-reducing experiment, participants can transfer €1,000 from the good state to the bad state, but only with an efficiency loss. This transfer reduces the dispersion of payoffs across states while also lowering the expected payoff. Thus, at the individual level, this task is formally equivalent to the leaky bucket experiment in the social setting. Conversely, in the risk-taking experiment, subjects can transfer €1,000 to the good state at the expense of the bad state, but now with an efficiency gain. This transfer increases both the dispersion of payoffs across states and

the overall expected payoff. At the individual level, this experiment is therefore formally equivalent to the productive pipeline experiment in the social setting.

To obtain a representative sample of the French population, we outsourced data collection to a French survey company called Bilendi, which has extensive experience in conducting such studies.[4] The representativeness of our sample is based on four demographic characteristics: age, gender, region of residence, and professional security contract (CSP). Our quotas for the different groups within each characteristic are set to match those reported by the National Institute of Statistics and Economic Studies (INSEE, https://www.insee.fr) for the years 2023 or 2024. As we shall see later, these demographic characteristics of our collected sample are fairly close to those of the broader population. To ensure sufficient observations for the different groups within each characteristic, with at least 150 people per group, we estimate a sample size of 3,000 respondents.

We preregistered our experiment in the AEA RCT Registry (ID: AEARCTR-0014855) and obtained ethical approval from the Toulouse School of Economics. Our instructions were in French, and a translated version is provided in Appendix D. A pilot with 50 respondents was initially conducted to test the functionality of the survey before launching it. Based on preliminary analysis of the pilot data, we made only a few changes in wording to simplify survey completion. However, the pilot data is not used in the following analysis. Our data collection officially started on 11th, December and ended on 30th, December. Targeted individuals received a link to access our survey. Upon entering, they first encountered a set of demographic questions that allowed us to verify their eligibility to complete the survey. Qualified respondents were then directed to the main choice experiment. At the end, they were asked to complete a survey assessing their political affiliation, perceptions of inequality in France, and etc. During the data collection phase, respondents could return at any time to complete the survey if they had not done so already. Notice that our survey itself was not monetarily incentivized. However, respondents who completed the survey successfully could receive credit from the survey company on their platform, which could be converted into real money in the future.

To guarantee data quality, we implemented both an attention check and consistency checks. For the attention check, respondents encountered a quiz in which they were asked to choose a specific option. An attentive respondent would have read the instructions carefully and chosen as requested. For the consistency checks, respondents were not allowed to switch back and forth between "Yes" and "No" more than once in either choice list. As long as their preferences are monotonic, we expect respondents to either initially choose "Yes" and then switch to "No" at some point (or never) and continue choosing it, or always choose "No". Respondents who failed to pass these tests were forced to quit the survey. Our final sample consisted of 3,010 French adults, with a median completion time of about 10 minutes.

[4] For instance, Douenne and Fabre (2022) recently collaborated with Bilendi to survey French people's attitudes towards carbon taxes.

2.2 *Main Results from the survey*

2.2.1 *Representativeness of the survey sample*

Before analyzing data from the choice experiments, we present four key demographic characteristics of our final sample: gender, age, professional security contract (CSP), and region. As Table E.1-E.4 in Appendix E show, our survey sample is fairly representative of the broader French population based on the most recent national census from the National Institute of Statistics and Economic Studies (INSEE, https://www.insee.fr). In total, our survey includes slightly more female respondents (49.57%) compared to the French population (47.57%). Regarding age groups, our survey sample aligns very closely with the population. When examining respondents' geographic origins, we find a slightly higher proportion from the northeastern part of France (22.56% versus 20.19%) and a lower proportion from the southwestern part (16.98% versus 18.71%). Finally, in terms of socio-professional categories (CSP), our sample comprises slightly more inactive individuals (45.18% versus 42.99%) and fewer individuals in the "Other Active" category (0.83% versus 5.18%), which includes farmers, craftsmen, and traders, compared to the broader French population. This discrepancy is primarily due to the greater ease of reaching inactive individuals and the relative difficulty of reaching those in the "Other Active" category during data collection.

2.2.2 *Experimental evidence of first-order inequality aversion*

For the following analysis, we exclude 518 inattentive respondents who consistently selected either "Yes" or "No" in all social allocation tasks, generating internally inconsistent choice patterns. For example, a respondent who always chose "Yes" would support a redistribution policy that transfers €1,000 from the rich to the poor even when the poor receive less than €100 (see Appendix D). At the same time, the same respondent would also approve a policy that grants €1,000 to the rich while imposing a cost exceeding €1,000 on the poor. This pattern reflects contradictory attitudes toward inequality rather than meaningful preferences. We therefore base our empirical analysis on the remaining 2,492 respondents.

Given our experimental design, we adopt a novel lexicographic approach that utilizes data from both the choice lists and open-ended questions. In the leaky bucket experiment, if a respondent starts choosing "No" at a given binary choice $i \in \{1,\dots,10\}$, then the minimum gain x given to the poor, required for them to accept a policy that takes €1,000 from the rich, falls within $[1000-100i, 1100-100i]$. We consider all respondents who switched at binary choice i and check whether their self-reported $\hat{x}$ falls within this range. We then compute the average of $\hat{x}$ for all consistent respondents and impute this value for all respondents who switched at binary choice i. Similarly, in the productive pipeline experiment, if a respondent switches from "Yes" to "No" at a given binary choice $i \in \{1,\dots,10\}$, then the maximum loss y borne by the poor, required for them to accept a policy that benefits the rich by €1,000, falls within the range $[100i-100, 100i]$. We consider all respondents who switched at binary choice i and check whether their self-reported $\hat{y}$ falls within this range. We then compute the average of $\hat{y}$

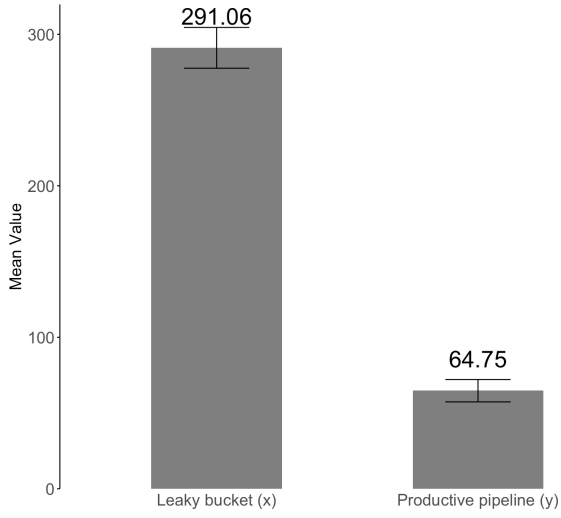


Figure 1. Comparison of mean responses in the leaky bucket and productive pipeline experiments.

for all consistent respondents and impute this value for all respondents who switched at binary choice i.

Figure 1 shows the average values of x and y from our survey experiment.[5] The average value of x is 291.06, with a standard deviation of 342.55, while the average value of y is 64.75, with a standard deviation of 188.10. We also observe a strong correlation between x and y ($\rho = 0.28$, $p < 0.001$). As we will show in section 3, utilitarianism predicts that the average values should be fairly close. However, among the french population, the average of x is more than four times larger than that of y. Specifically, we reject the null hypothesis that x is equal to y at any conventional significance level (paired t-test, $p < 0.001$). At the individual level, 92.78% of our respondents have a value of x strictly larger than that of y, 5.90% have a lower value, and 1.32% have an equal value.

Table 1 presents the distributions of x and y, both of which are highly right-skewed. In the leaky bucket question, 53.17% of our respondents had a value of x between 0 and €100, therefore accepting a redistribution policy that resulted in an efficiency loss of at least €900, implying an extremely high level of inequality aversion. This figure becomes even more pronounced in the productive pipeline question: 84.11% of the respondents had a value of y between 0 and €100 and were unwilling to sacrifice the poor for €100 in order to grant the rich a benefit of €1,000. Namely, respondents are much more likely to exhibit extreme levels of inequality aversion in the productive pipeline experiment.

Assume that respondents behave as utilitarians in each experiment but exhibit varying degrees of inequality aversion. Furthermore, the utility function belongs to the CRRA family. Using maximum likelihood estimation and assuming a log-normal distribution

[5] We obtain similar results without using the open-ended questions. The average value of x is 278.61, with a standard deviation of 342.54, while the average value of y is 60.19, with a standard deviation of 187.92. See the distributions of x and y in Table E.5.

x	Percentage (x)	y	Percentage (y)
15.15	53.17	4.27	84.11
100.00	1.81	105.42	5.94
204.55	3.17	206.67	2.29
312.50	2.61	300.00	1.24
400.00	5.90	441.00	0.84
500.94	9.71	500.00	1.44
600.00	3.77	600.00	0.80
715.63	4.53	725.00	0.56
810.00	4.70	800.00	0.32
934.14	7.78	900.00	0.44
1000.00	2.85	1000.00	2.01

Table 1. Distributions of x and y in the social allocation tasks

for both x and y,[6] given that both are right-skewed (see Table 1), we estimate the degree of inequality aversion at the aggregate level to be 2.32 (SD = 0.03) in the leaky bucket experiment, and 4.33 (SD = 0.03) in the productive pipeline experiment. Therefore, respondents exhibit significantly greater inequality aversion in the productive pipeline experiment than in the leaky bucket experiment. In section 3, we will propose an alternative model with first-order inequality aversion at the lower income level to account for this observation and structurally estimate it using our experimental data.

2.2.3 *Risk attitudes in the individual risk tasks*

In this section, we exploit the two risk tasks to estimate the intensity of risk aversion. We exclude 1,575 inattentive respondents who consistently selected either "Yes" or "No" across all individual risk tasks, resulting in internally inconsistent choice patterns. Additionally, the data from open-ended questions appear extremely noisy, possibly because these questions were relatively harder to understand compared to those in the social allocation tasks. Therefore, we rely solely on choice data for the subsequent analysis and base our empirical investigation on the remaining 1,435 respondents.

Figure 2 shows the average values of x and y in the risk-reducing and risk-taking experiments. The mean value of x is 499.02 (SD = 431.73), while the mean value of y is 434.56 (SD = 432.52). Assuming a CRRA utility function and using non-linear least squares, these average values correspond to coefficients of relative risk aversion of 0.63 (SD = 0.03) and 0.76 (SD = 0.03). We also observe a strong positive correlation between x and y ($\rho = 0.47$, $p < 0.001$), which is notably stronger than the correlation observed in the social allocation tasks, suggesting greater consistency in risk preferences. Additionally, there is a significant difference between x and y, with participants exhibiting

[6] When we perform a goodness-of-fit comparison, the log-normal distribution displays the lowest AIC and BIC values, outperforming other commonly used distributions such as the gamma and normal distributions. Using normal distributions for x and y would yield an estimated γ of 1.14 for the leaky bucket experiment and 2.47 for the productive pipeline experiment.

Values	Percentage (x)	Percentage (y)
0	33.52	38.68
100	4.88	5.30
200	2.16	4.25
300	1.25	2.72
400	6.90	3.97
500	4.04	7.04
600	1.95	1.39
700	2.16	1.32
800	2.79	1.11
900	14.36	7.18
1000	25.99	27.04

Table 2. Distributions of x and y in the individual risk tasks

greater risk aversion in the risk-taking experiment. It is worth noting that the difference is much smaller than our increment of 100 and could therefore potentially be attributed to measurement error. Pooling data from both experiments yields an average of 466.79 (SD = 370.66). Assuming a CRRA utility function and using non-linear least squares, this corresponds to a coefficient of relative risk aversion of 0.70 (SD=0.03).

Barsky et al. (1997) used another experimental design to estimate risk aversion. Starting from an initial risk-free lifetime income, respondents must choose between this status quo and a risky lifetime alternative involving a 50-50 chance of either doubling that lifetime income or reducing it by one-third or one-fifth. They observe a very low intensity of relative risk tolerance of 0.2412, which is equivalent to a relative risk aversion of 4.15, almost 6 times larger than our own estimation. The permanence of the income shock in their experiment may explain the difference.

3. First-order inequality aversion

In this section, we assume that the respondents use the concept of the veil of ignorance when solving the two social allocation tasks of the survey. Let w_ℓ and $w_h = kw_\ell > w_\ell$ be the income levels of the poor party and the rich party, respectively. In the survey, k equals 3. The monetary unit is hereafter equal to €1,000. The continuous utility function on income is denoted $u(.)$. Its first derivative is assumed to be decreasing and piecewise continuous.

In the leaky bucket experiment, the minimum gain for the poor to compensate for the loss of 1 for the wealthy is denoted x, which is determined as follows:

$$\frac{1}{2}u(w_\ell + x) + \frac{1}{2}u(w_h - 1) = \frac{1}{2}u(w_\ell) + \frac{1}{2}u(w_h). \tag{1}$$

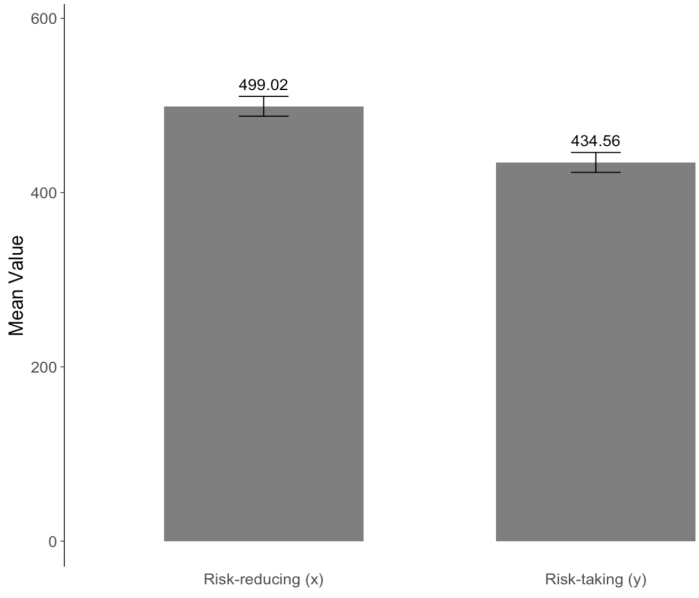


Figure 2. Comparison of mean responses in the risk-taking and risk-reducing experiments.

In the small,[7] this is equivalent to

$$x = \frac{u'_-(w_h)}{u'_+(w_\ell)}. \tag{2}$$

Symmetrically, in our reverse bucket experiment, the maximum loss y for the poor to generate a unit gain for the wealthy is such that

$$\frac{1}{2}u(w_\ell - y) + \frac{1}{2}u(w_h + 1) = \frac{1}{2}u(w_\ell) + \frac{1}{2}u(w_h). \tag{3}$$

In the small, this is equivalent to

$$y = \frac{u'_+(w_h)}{u'_-(w_\ell)}. \tag{4}$$

The following proposition is a direct consequence of equations (2) and (4).

PROPOSITION 1. *The leaky bucket and the reverse bucket experiments yield the same solution $x = y$ whenever the social utility function u is continuously differentiable.*

In the case of a continuously differentiable utility function, we have that x and y must be equal. As shown earlier, this is strongly contradicted by our survey data, where y is significantly lower than x.

[7] One may argue that our questions in the survey do not address marginal transfers, as 1,000 euros is taken from or given to the rich person. However, using these preference parameters, the comparison of the exact value of x from equation (1) and the one from its approximation (2) gives an error of 2.6%.

To solve this puzzle, we must assume that u' is discontinuous at w_ℓ or at w_h. In the spirit of Rawls (1971), we hereafter assume that the discontinuity takes place only at $w_\ell = \min\{w_\ell, w_h\}$. This income level serves as the reference point. More specifically, we assume the following functional form:

$$u'(w; w_\ell) = \begin{cases} \eta w^{-\gamma}, \text{ if } w \leq w_\ell, \\ w^{-\gamma}, \text{ if } w > w_\ell, \end{cases} \tag{5}$$

with $\eta > 1$. Observe that the intensity of relative inequality aversion $-u''(w; w_\ell)/u'(w; w_\ell)$ is equal to γ whenever $w \neq w_\ell$, and is unbounded locally at $w = w_\ell$. As is well-known from decision theory (Segal and Spivak, 1990), the presence of a concave kink in the utility function identifies first-order aversion. This means that around w_ℓ, the risk or inequality premium associated with a spread $k\xi$ with $E[\xi] = 0$ and $k \in \mathcal{R}$ is proportional to k in the neighborhood of $k = 0$, yielding first-order aversion. With a continuously differentiable utility function this premium is proportional to k^2, as shown by the Arrow-Pratt approximation (Pratt, 1964). A limit case is when η tends to infinity, which corresponds to the Rawlsian "difference" – or "maximin" – principle.

This two-parameter utility function is compatible with respondents providing different answers to the leaky bucket and reverse bucket experiments. In particular, any given pair of answers (x, y) is compatible with a pair of preference parameters (γ, η) defined as follows:

$$\gamma = \gamma_x = -\frac{ln(x)}{ln(k)} \tag{6}$$

$$\eta = \frac{x}{y} \tag{7}$$

Using data from both the leaky bucket and productive pipeline questions, along with maximum likelihood under the assumption of log-normal distributions, we estimate the parameter pair (γ, η) at the aggregate level. Our results yield an estimate of $\gamma = 2.29$ with a standard deviation of 0.03 and an estimate of $\eta = 9.74$ with a standard deviation of 0.47.[8] The corresponding utility function is drawn in Figure 3. In Table 3, we summarize the three estimations of the collective utility function u, respectively using only the leaky bucket experiment, only the productive pipeline experiment, and the combination of the two experimental designs. It is noteworthy that adding the data from the productive pipeline experiment, which favors more inequality aversion, translates into recognizing FOIA with a large η rather than raising the γ coefficient.

When measuring inequality aversion, most experiments have focused on the leaky bucket experiments or on experiments where respondents are required to elicit their willingness to pay for a reduction of inequalities. These experiments do not provide a methodology to identify first-order inequality aversion. Thus, by combining the leaky bucket experiment with the productive pipeline experiment, we are, to our knowledge,

[8] The MLE estimators under the assumption of normal distributions are $\gamma = 1.12$ and $\eta = 4.49$. Notice also that an individual with $\gamma = 2.29$ and $\eta = 9.74$ would answer as follows to the two inequality questions: $x = 81$ euros and $y = 27$ euros.

experiment	η	γ
leaky bucket	1.00	2.32
productive pipeline	1.00	4.33
combined	9.74	2.29

Table 3. Three estimations of the bivariate social utility function u. The first two estimations are based on the assumption that $\eta = 1$ and use respectively only the leaky bucket experiment or only the productive pipeline experiment. The third estimation combines the two experiments. All estimations are based on a log normal distribution of errors.

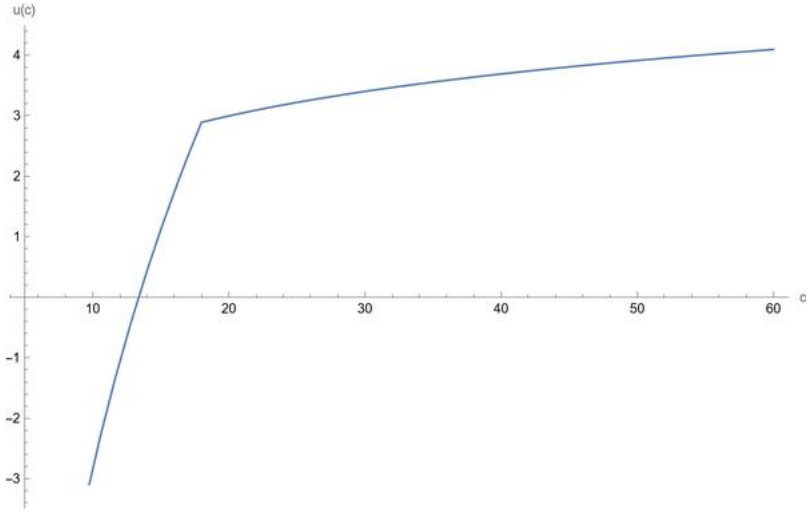


Figure 3. Calibrated utility function with first-order inequality aversion: $\gamma = 2.29$ and $\eta = 9.74$.

the first to estimate social preferences with first-order inequality aversion. Estimation of the discontinuity of marginal utility is more advanced in the domain of risk. The coefficient η is referred to as "loss aversion" in that literature. A loss aversion coefficient of $\eta = 2$ is representative of the estimates obtained from experimental analyzes, so that losses weigh twice as much as the corresponding gains (Abdellaoui et al., 2016). This confirms the initial finding of Kahneman and Tversky (1979). Our results suggest a considerably larger degree of first-order inequality aversion. Even without this kink in the utility function at the low income level, our estimation of its concavity in the two branches of the curve, with $\gamma = 2.29$ is much larger than in the two existing estimates from the leaky bucket experiment, as obtained respectively by Amiel and Cowell (1999) (with a γ around 0.1-0.2) and Pirttila and Uusitalo (2010) (with a γ below 0.5).

4. Discounting under certainty

In this section, we determine the rate at which a specific benefit materializing in t years should be discounted in the absence of uncertainty but with first-order inequality aversion. We assume in this section that t is large enough so that the transfer concerns two different generations. Let c_0 and c_t denote consumption levels on dates 0 and t, respectively. The preferences of the social planner exhibit first-order inequality aversion. This means that it maximizes the sum over $\tau \in \{0,t\}$ of generational utilities $u(c_\tau; w_\ell)$, where w_ℓ is defined as the smallest consumption level of the two generations involved in the transfer, and where the function u is specified by equation (5).

Suppose first that c_0 is smaller than c_t, so that the planner's reference point is $w_\ell = c_0$. This implies that the present value v_0 of a sure benefit $\varepsilon > 0$ in t years must be such that

$$u(c_0 - v_0; c_0) + u(c_t + \varepsilon; c_0) = u(c_0; c_0) + u(c_t; c_0). \tag{8}$$

From this present value v_0, we can derive the efficient discount rate r_{ft} from the observation that v_0 must be equal to the present value of ε discounted at rate r_{ft}. In the small, the above equation is equivalent to

$$r_{ft} = -\frac{1}{t}\ln\left(\frac{u'_+(c_t;c_0)}{u'_-(c_0;c_0)}\right) = -\frac{1}{t}\ln\left(\frac{c_t^{-\gamma}}{\eta c_0^{-\gamma}}\right). \tag{9}$$

Suppose alternatively that the economy is shrinking, so that c_0 is larger than c_t. In that case, the present value v_0 of a sure benefit ε materializing in t years must be such that

$$u(c_0 - v_0; c_t) + u(c_t + \varepsilon; c_t) = u(c_0; c_t) + u(c_t; c_t) \tag{10}$$

In the small, this implies that

$$r_{ft} = -\frac{1}{t}\ln\left(\frac{u'_+(c_t;c_t)}{u'_-(c_0;c_t)}\right) = -\frac{1}{t}\ln\left(\frac{c_t^{-\gamma}}{c_0^{-\gamma}}\right). \tag{11}$$

Equations (9) and (11) directly yields the following proposition.

Proposition 2. *Let $g_t = (1/t)\ln(c_t/c_0)$ denote the annualized growth rate of consumption between dates 0 and t. Under certainty, the efficient discount rate associated to maturity t is*

$$r_{ft} = \begin{cases} \gamma g_t \text{ if } g_t \le 0, \\ \gamma g_t + t^{-1}\ln(\eta) \text{ if } g_t > 0. \end{cases} \tag{12}$$

In the special case without first-order inequality aversion, i.e., when $\eta = 1$, we recover the Ramsey rule $r_{ft} = \gamma g_t$. The Ramsey rule also holds when growth is negative, regardless of the intensity of η. Indeed, in this case, investing for the future transfers consumption from the current rich to the future poor, so that FOIA is irrelevant in this case. On the contrary, when growth is positive, investing transfers consumption from the poor

to the wealthy, and first-order inequality aversion matters. Its impact is large for small maturities, where the kink of the utility function at the reference consumption level c_0 adds significantly to its concavity. In fact, the local measure of inequality aversion at c_0 is unbounded, so is the efficient discount rate for short maturities. This result is reminiscent of the well-known observation that the Rawlsian maximin rule leads to infinite discount rates for all maturities when growth is positive (Arrow, 1973). In our framework, this result holds only for small maturities. As we consider larger maturities, the kink in u at c_0 becomes less relevant for measuring the ratio of marginal utilities at the two dates, and the efficient discount rate tends to the Ramsey rate γg_t when t approaches infinity.

Using our estimation from the survey data with $\eta = 9.74$, FOIA raises the discount rate relative to maturity t by $2.28/t$. To illustrate, FOIA raises the discount rate from γg_{100} to $\gamma g_{100} + 2.28\%$ for a 100-year time horizon. This is large.

The model of intertemporal transfers presented in this section suffers from the unrealistic assumption that any transfer of consumption from date 0 to date t is necessarily an interpersonal transfer, which raises the issue of interpersonal inequalities. In reality, when t is small, most of the initial sacrifice benefits the same generation and generates no interpersonal transfer. This problem must be solved using an overlapping generation model. This is what we do in the next section.

5. Discounting with ex-ante FOIA and OLG

In this section, we explore an overlapping generation model with FOIA under uncertainty. We use the "perpetual youth" model of Yaari (1965) and Blanchard (1985). At date 0, there is a population of unit size that enjoys a per capita consumption of c_0. At the end of each period, a proportion $1-p$ of the population dies and is replaced by a new generation of size $1-p$, so the population remains constant. Parameter p is the survival probability. There is no inequality within each period, so consumption is independent of age. Consumption evolves over time according to a discrete version of a geometric brownian process, such that $c_{\tau+1} = c_\tau e^{g_\tau}$ for any nonnegative integer τ, with $g_0, g_1, ...$ being i.i.d. $N(\mu, \sigma^2)$. This growth process generates intergenerational inequalities.

Individual preferences satisfy the DEU criterion, with CRRA α and the utility-discount factor δ. The α risk aversion will be calibrated based on our risk experiments. Under the DEU criterion, one can estimate y_τ, which denotes the constant-equivalent consumption level of an individual born on date τ, conditional on all information available at that date. It is characterized as follows:

$$\frac{y_\tau^{1-\alpha}}{(1-\alpha)(1-p\delta)} = \sum_{i=0}^{\infty} p^i \delta^i \frac{E_\tau[c_{\tau+i}^{1-\alpha}]}{1-\alpha} = c_\tau^{1-\alpha} \sum_{i=0}^{\infty} p^i \delta^i \frac{e^{(1-\alpha)\mu i + 0.5(1-\alpha)^2\sigma^2 i}}{1-\alpha}. \tag{13}$$

This implies that

$$y_\tau = \left(\frac{1-p\delta}{1-p\delta e^{(1-\alpha)\mu + 0.5(1-\alpha)^2\sigma^2}} \right)^{\frac{1}{1-\alpha}} c_\tau = k_1 c_\tau. \tag{14}$$

Thus, the constant-equivalent consumption level y_τ for generations born on date τ is growing at the same rate as temporal consumption levels c_τ.

There are two possible approaches to aggregate generational welfare levels with FOIA. Under the "ex ante" approach, generational utility comparisons are performed at date 0, given all information available at that time. Welfare comparisons are performed here through the generational certainty-equivalent constant-equivalent consumption levels viewed from date 0. When the risk-adjusted expected growth rate of c_τ is positive, the current generation is considered the poorer party in the transfer from this party to each of the receiving parties (each generation born between 0 and t). The FOIA criterion with parameters (γ, η) is used to measure intergenerational welfare in this context. The opposite is true when the risk-adjusted expected growth rate is negative.

Alternatively, under the "ex post" approach, the direction of the inequality between the donor (current generation) and each receiver (future generation) is considered ex post in each state of nature occurring at the birth date of this receiver. Therefore, the poorer agent may well be the current generation in some states of nature and birth dates, and the future generation in others.

These two approaches based on ex ante or ex post generational welfare comparisons yield different discounting systems under first-order inequality aversion.

5.1 *Discounting with ex-ante FOIA*

Under the ex ante approach, generational welfare comparisons are performed at date 0 conditional on information available at that date. As shown in Appendix A, the certainty-equivalent constant-equivalent consumption level $\overline{y}_\tau$ grows at a rate $g = \mu + 0.5(1-\alpha)\sigma^2$, which may be positive or negative.

As is standard in the asset pricing literature, we consider an investment project that generates a single payoff c_t^β at date t per dollar invested at date 0. This covers the case of a risk-free project ($\beta = 0$), a claim on aggregate consumption ($\beta = 1$), or, more generally, any claim with a constant income-elasticity β. In the CCAPM, the β parameter is called the CCAPM beta. The following proposition is proven in Appendix A.

PROPOSITION 3. *Under the ex ante approach, the efficient discount rate for a payoff c_t^β occurring at date t is characterized by the following equation if $g = \mu + 0.5(1-\alpha)\sigma^2$ is positive:*

$$\rho_t^{ante} = r_\alpha - \frac{1}{t}\ln\left(1 + \frac{1-p}{\eta}\frac{1-h^t}{h^{-1}-1}\right) \leq r_\alpha, \tag{15}$$

with

$$r_\alpha = -\ln(p\delta) + \alpha\mu - 0.5\alpha^2\sigma^2 + \beta\alpha\sigma^2, \tag{16}$$

and

$$h = (p\delta)^{-1}\exp((\alpha-\gamma)g). \tag{17}$$

When g is negative, the same discounting system applies with $\eta = 1$.

PROOF. See Appendix A. □

It is easy to demonstrate that Proposition 2 is a special case of this new proposition when $\sigma = 0$ (no uncertainty) and $p = 0$ (each generation lives only one period). Under uncertainty ($\sigma > 0$) but without overlapping generations ($p = 0$), we obtain this limit case:

$$p = 0 \Rightarrow \rho_t^{ante} = r_{\gamma\alpha} + \frac{1}{t}\ln(\eta) \tag{18}$$

with

$$r_{\gamma\alpha} = \gamma\mu - 0.5\alpha^2\sigma^2 + \beta\alpha\sigma^2 + 0.5(\gamma - \alpha)(1 - \alpha)\sigma^2. \tag{19}$$

Equation (18) is reminiscent of the case of certainty with a hyperbolically decreasing term structure of discount rates. The risk-adjusted discount rate $r_{\gamma\alpha}$ defined in (19) has a second-order inequality term $\gamma\mu$ corresponding to the Ramsey rule. Three additional terms, all proportional to σ^2, appear in this formula. The first of these terms is a precautionary term, whereas the second one is the CCAPM risk-adjustment standard in the CCAPM. It is proportional to the beta of the asset under scrutiny. Finally, the last term in σ^2 comes from the fact that the certainty-equivalent growth rate of consumption is $g = \mu + 0.5(1 - \alpha)\sigma^2$ rather than just μ.

In the dual case with infinitely living consumers ($p = 1$), the efficient discount rate ρ_t^{ante} equals r_α, which is the standard CCAPM risk-adjusted discount rate with CRRA α. It yields a CCAPM risk-free rate $-\ln(\delta) + \alpha\mu - 0.5\alpha^2\sigma^2$ and a CCAPM risk premium $\alpha\sigma^2$.

Proposition 3 implies that the risk-adjusted discount rates are always smaller than r_α, the rates that would prevail if the first generation would live forever. Moreover, by construction, an important property of the efficient discounting system under ex ante FOIA is that the aggregate risk premium and the precautionary premium are entirely determined by consumers' risk aversion α. FOIA only affects the term structure of the risk-free rate. The short-term discount rate in the limit case of continuous time is given by

$$\rho_0^{ante} = r_\alpha - \frac{1 - p}{\eta(1 - h^{-1})}\ln(h). \tag{20}$$

The negative difference $\rho_0^{ante} - r_\alpha$ vanishes linearly with the death probability $1 - p$. The important point here is that the overlapping generation model considered in this section eliminates the problematic unboundedness of the short-term discount rate observed in Proposition 2.

For long maturities, we obtain the following property:

$$lim_{t\to\infty}\rho_t^{ante} = \begin{cases} r_\alpha, & \text{if } h \le 1, \\ r_{\gamma\alpha}, & \text{if } h > 1. \end{cases} \tag{21}$$

Notice first that FOIA is irrelevant for long maturities, as already observed in Proposition 2 in the certainty case. Second, two competing discount rates, r_α and $r_{\gamma\alpha}$, are candidates for the asymptotic value of ρ_t^{ante}. When h is larger than unity, $r_{\gamma\alpha}$ wins. This happens

when the survival probability is small, or when γ is smaller than α in a growing economy ($g > 0$). Otherwise, when h is smaller than unity, r_α wins, and the term structure of discount rates has an upward shape, in the sense that ρ_∞^{ante} is larger than ρ_0^{ante}.

5.2 *Discounting with ex-post FOIA*

In this section, I assume that inequality valuation is made ex post, comparing the lifetime utility of the donor (generation 0) with those of each receiving generation when they are born. As proven in Appendix B, it yields the following characterization of the efficient discounting system.

PROPOSITION 4. *Under the ex post approach, the efficient discount rate for a single payoff c_t^β occurring at date t is characterized by the following equation:*

$$\rho_t^{post} = r_\alpha - \frac{1}{t}\ln\left(1 + (1-p)\sum_{\tau=1}^{t} e^{(r_\alpha - r_\gamma)\tau}\left(q_\tau + \eta^{-1}(1-q_\tau)\right)\right), \tag{22}$$

where r_α is defined by equation (16),

$$r_\gamma = \gamma\mu - 0.5\gamma^2\sigma^2 + \beta\gamma\sigma^2, \tag{23}$$

and

$$q_\tau = P\left[z \leq -\frac{\mu + (\beta-\gamma)\sigma^2}{\sigma}\sqrt{\tau} \mid z \sim N[0,1]\right]. \tag{24}$$

PROOF. See Appendix B. □

When $\beta = 0$, q_τ can be interpreted as the probability that generation τ be endowed at birthday by a lifetime utility that is smaller than the current generation's utility.

It is easy to check that $\rho_t^{post} = \rho_t^{ante}$ for all t when there is no uncertainty ($\sigma = 0$). Indeed, under certainty, the ex post approach always gives a probability $q_\tau = 0$ (resp. 1) for future generations to be poorer than the current generation when μ is positive (resp. negative). Notice also that when the survival probability p is equal to 1, the efficient discount rate ρ_t^{post} equals r_α for all t, since there is only one generation and no inequality in that case.

For short maturities, the efficient discount rate is approximately equal to

$$\rho_0^{post} \simeq r_\alpha - 0.5(1-p)(1+\eta^{-1}), \tag{25}$$

which is smaller than r_α. This means in particular that the short-term aggregate risk premium is $\gamma\sigma^2$, which is as under the ex ante approach. For long maturities, we obtain the following characterization, as proven in Appendix C.

$$lim_{t\to\infty}\rho_t^{post} = \min\{r_\alpha, r_\gamma\}. \tag{26}$$

parameter	value	justification
η	9.74	our survey: leaky bucket and productive pipeline experiments
γ	2.29	our survey: leaky bucket and productive pipeline experiments
α	0.70	our survey: risk experiments
δ	1	impatience originates only from death probability
p	0.988	life expectancy around 82 years
μ	0.0206	Christensen, Gillingham and Nordhaus (2018)
σ	0.1062	Christensen, Gillingham and Nordhaus (2018)

Table 4. Calibration of the parameters of the pricing model

5.3 *Calibration*

We calibrate the preference parameters of these two asset pricing models by using the outcomes of our survey. In particular, the intergenerational aggregation is performed using the bivariate utility function u characterized by equation (5) with $\gamma = 2.29$ and $\eta = 9.74$. Individual intertemporal preferences satisfy DEU with constant relative risk aversion $\alpha = 0.7$ and no pure preference for the present ($\delta = 1$). The survival probability p is equal to 98.8%, which yields a life expectancy around 82 years. It gives people an indirect preference for the present (Stern, 2007).

Calibrating the parameters of the consumption dynamics under the assumption of a geometric brownian process yields the well-known asset pricing puzzles (Weil, 1989, Epstein and Zin, 1989, 1991). In particular, the aggregate risk premium $\pi = \alpha\sigma^2$ obtained with infinitely lived consumers is a fraction of what is observed on financial markets. The asset pricing literature has developed various arguments against representing economic growth in the brownian framework. For example, Bansal and Yaron (2004) assume that both the mean and the volatility of the change in log consumption follow an autoregressive process of order one. This fattens the tails of the distribution of future log consumption (Gollier, 2018). Barro (2006, 2009) showed how the existence of rare macroeconomic catastrophes can solve the asset pricing puzzles. Collin-Dufresne, Johannes and Lochstoer (2016) and Gollier (2016) explored the impact of learning on asset prices when the parameters of the i.i.d. process of growth are uncertain, with illustrations to an uncertain trend or volatility of consumption growth. All these departures from the standard brownian framework imply a magnification of long-term uncertainty. This is in line with the perception that long-term uncertainties are deeper than the accumulation of short-term shocks. In this paper, we calibrate our models using a survey from Christensen, Gillingham and Nordhaus (2018). In 2010, they used 13 probabilistic expert forecasts to aggregate beliefs about the growth of global real per-capita GDP between 2010 and 2100. From these expert beliefs, they estimate the parameters of $x_t \sim N(\mu t, \sigma^2 t)$. They obtain $\mu = 2.06\%$ and $\sigma = 10.62\%$. It is noteworthy that this annual volatility of growth is much larger than the historical standard deviation of annual growth rates of western economies. Our calibration is summarized in Table 4.

Two benchmark discounting systems, r_α and r_γ, should be kept in mind at this stage. Table 5 summarizes them. Under an infinitely lived generation ($p = 1$), keeping the other

discounting system	risk-free rate	aggregate risk premium
r_α	2.37%	0.80%
r_γ	1.76%	2.58%

Table 5. Two CCAPM discounting systems, where the risk adjusted discount rate is the sum of the risk-free rate and β times the aggregate risk premium.

parameters in Table 4 unchanged, system r_α will be efficient, with a risk-free rate and an aggregate risk premium equal to 2.37% and 0.8%, respectively. This corresponds to the CCAPM rates under the constant relative risk aversion $\alpha = 0.70$ and a rate of pure preference for the present $-\ln(p\delta)$. The alternative benchmark discounting system r_γ is based on the relative risk aversion γ with no impatience and no FOIA, which would yield a risk-free rate $\gamma\mu - 0.5\gamma^2\sigma^2 = 1.76\%$ and an aggregate risk premium $\gamma\sigma^2 = 2.58\%$.

Let us start with the ex ante approach to asset pricing with FOIA. Under that approach, the aggregate risk premium is the CCAPM one with risk aversion α. This means that the risk adjustment of the discount rate above the risk-free rate equals 0.80% times the project-specific beta. Because of the relatively small level of α calibrated from our risk experiments, these risk premia are too small compared to the market observations.

The term structure of the risk-free rates in the ex ante approach is moderately increasing, as shown in Figure 4. The short term risk-free rate equals ρ_0^{ante} =2.25%, growing up to r_α =2.37% when t tends to infinity. This is because $h = 0.977$ is smaller than unity. In Figure 4, we also draw the term structure of the risk-free rates that would prevail if one would have estimated the relative inequality aversion from the data of the leaky bucket design, thereby ignoring FOIA. As in the certainty case examined in Proposition 2, FOIA raises short-term interest rates, with the important difference of not pushing them to infinity when t tends to zero.

In the ex post approach, because $\mu - \gamma\sigma^2$ is negative, the probability $q_\tau[\beta = 0]$ is increasing from 1/2 to 1 when τ goes from 0 to infinity. This implies that the risk-free rate tends to $r_\gamma = 1.76\%$ asymptotically. We draw its term structure in Figure 5. This term structure is slightly hump-shaped. To measure the impact of FOIA, we compare this term structure to the one that would be efficient under the alternative calibration with $\eta = 1$ and $\gamma = 2.32$ that supports the data from the leaky bucket responses only. As in the ex ante approach, FOIA has the impact to raise the short-term risk-free rates.

Remember that in the ex ante approach, the aggregate risk premium is a constant $\alpha\sigma^2 = 0.80\%$. This is not the case in the ex post approach. Indeed, the risk profile β appears twice in the right-hand side of the equation (22) that characterizes ρ_t^{post}. It appears in r_α linearly as is standard in the CCAPM, but it also appears in probability q_τ, as shown in equation (24). The term structure of risk premia is represented in Figure 6. As shown in equation (25), it starts at $\alpha\sigma^2 = 0.8\%$. From equation (26) and given the fact that $r_\alpha > r_\gamma$ when $\beta = 0$ and the opposite when $\beta = 1$, the risk premium tends asymptotically to $r_\alpha[\beta = 1] - r_\gamma[\beta = 0]$, which is equal to 1.41%. Notice that FOIA has only a marginal impact on the aggregate risk premia.

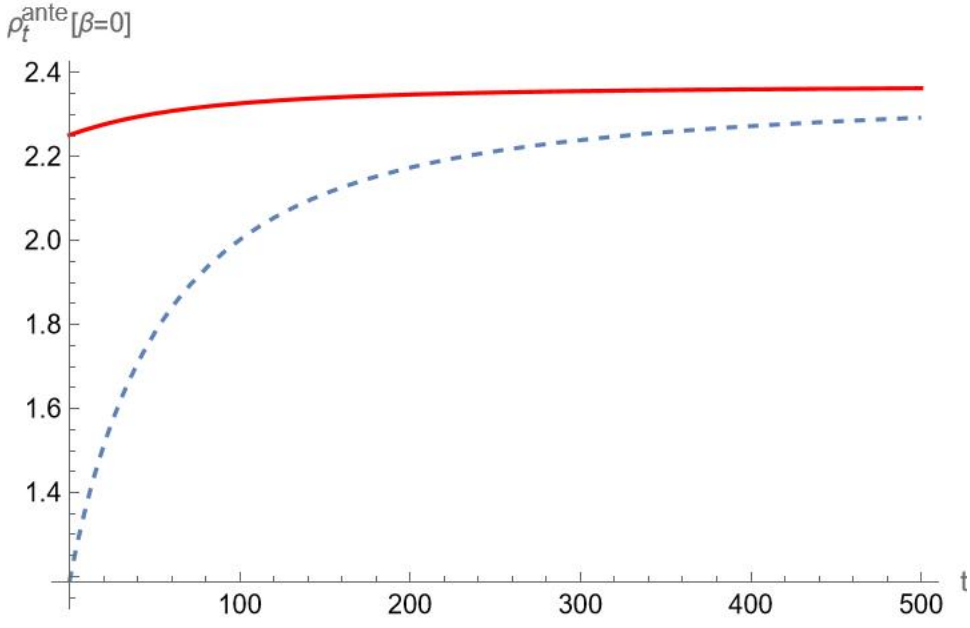


Figure 4. Term structure of the risk-free interest rates (in %) under the ex ante approach. The plain curve corresponds to the benchmark calibration of Table 4. The dashed curve is obtained by replacing η and γ respectively by $\eta = 1$ and by $\gamma = 2.32$, the estimation of the inequality aversion from the leaky bucket question.

It is noteworthy that the efficient risk-free rates generated by the two approaches, with $\rho_t^{ante}[\beta = 0] \simeq 2.3\%$ and $\rho_t^{post}[\beta = 0] \simeq 1.7\%$ are not far from those that have recently been recommended in the United States (2%), in Canada (2.3%), and in France (1.2%). This is a surprising result, as the respondents to our survey appeared to be much more inequality-averse than the standard calibration of the Ramsey rule used in these countries.

6. Conclusion

Despite the importance of this key parameter in macroeconomics, finance, and cost-benefit analysis, considerable uncertainty surrounds the magnitude of the elasticity of marginal utility. In the Discounted Expected Utility framework often used in welfare economics, this parameter measures at the same time risk aversion, inequality aversion, and the willingness to smooth consumption over time. These three elements matter for the characterization of the efficient intergenerational discounting system.

The contributions of this paper to the literature on social discounting have two dimensions. First, we document the outcomes of an innovative survey in which respondents are requested to perform two sets of tasks, addressing their attitudes towards inequality and risk, respectively. These data exhibit more inequality aversion than risk aversion, in contradiction to the concept of the veil of ignorance. We recognize in this

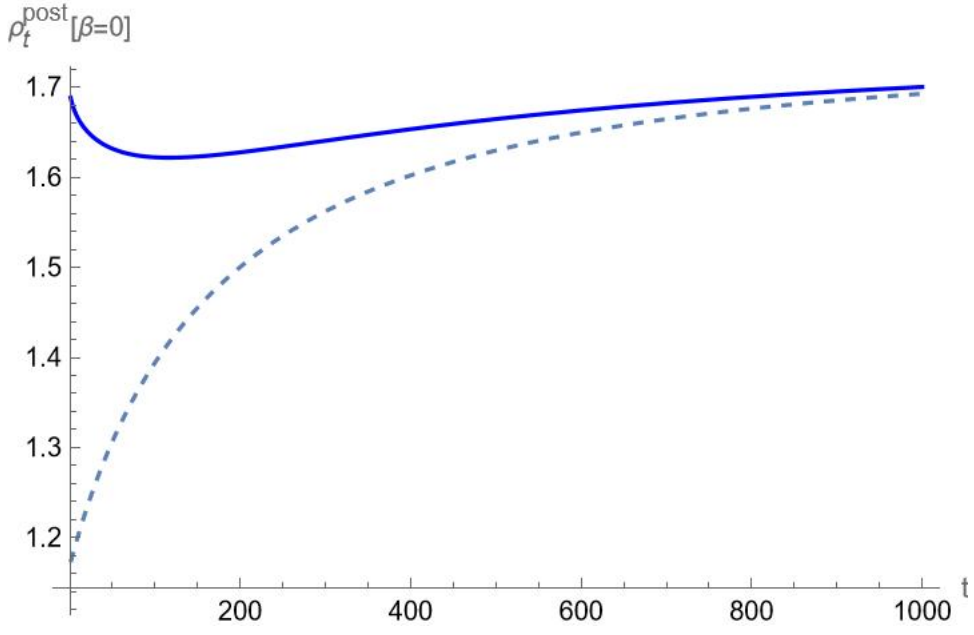


Figure 5. Term structure of the risk-free interest rates (in %) under the ex post approach. The plain curve corresponds to the benchmark calibration of Table 4. The dashed curve is obtained by replacing η and γ respectively by $\eta = 1$ and by $\gamma = 2.32$, the estimation of the inequality aversion from the leaky bucket question.

paper that the attitude toward risk may be contextual. Namely, the attitude toward individual lottery risks can differ from the attitude toward social risks, even when they are probabilistically equivalent. We also document the presence of first-order inequality aversion, with most respondents being much more reluctant to trade more inequality for more prosperity than to trade less prosperity for less inequality.

Second, we assemble these different outcomes of our survey in a new theoretical discounting model that encompasses both the Ramsey rule and the CCAPM. It is based on an overlapping generations model in which individuals use the DEU framework to evaluate their lifetime utility, using a moderately concave utility function. An intergenerational welfare aggregator is then used with a piecewise CRRA utility function that has a discontinuity in marginal utility at the lower consumption level of the generations involved in the intertemporal transfer. We derive analytical solutions for efficient risk-adjusted discount rates. Their calibrations based on our survey yield risk-free discount rates that align with the current expert consensus of around 2%. This is a surprising result, as the respondents to our survey appeared to be much more inequality-averse than in the standard calibration of the Ramsey rule.

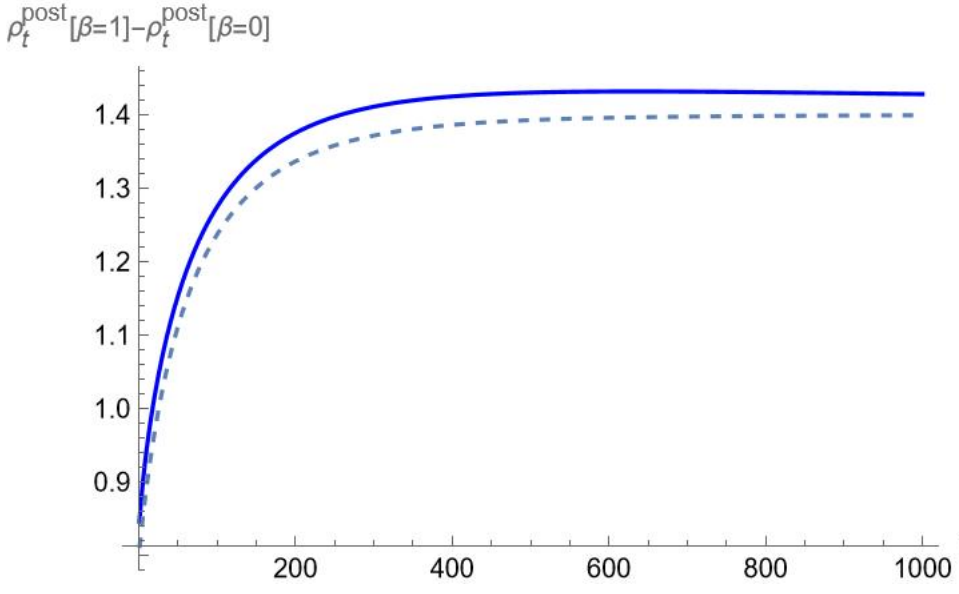


Figure 6. Term structure of the aggregate risk premia $\rho_t^{post}[\beta = 1] - \rho_t^{post}[\beta = 0]$ (in %) under the ex post approach. The plain curve corresponds to the benchmark calibration of Table 4. The dashed curve is obtained by replacing η and γ respectively by $\eta = 1$ and by $\gamma = 2.32$, the estimation of the inequality aversion from the leaky bucket question.

ACKNOWLEDGEMENT

Gollier and van der Straeten acknowledge the funding from the Agence Nationale de la Recherche under grant ANR-17-EURE-0010. Zheng acknowledges the funding from the Agence Nationale de la Recherche under grant ANR-17-EURE-0020, from Excellence Initiative of Aix-Marseille University-A*MIDEX, and from the National Natural Science Foundation of China (Grant no. 72303232).

APPENDIX A: PROOF OF PROPOSITION 3

Because the welfare y_τ of generation τ is uncertain at date 0, its certainty-equivalent constant-equivalent consumption level $\overline{y}_\tau$ must satisfy the following condition:

$$\overline{y}_\tau^{1-\alpha} = E_0\left[y_\tau^{1-\alpha}\right] = k_1^{1-\alpha} E_0\left[c_\tau^{1-\alpha}\right] = k_1^{1-\alpha} c_0^{1-\alpha} e^{(1-\alpha)\mu\tau + 0.5(1-\alpha)^2\sigma^2\tau}. \tag{27}$$

This implies that

$$\overline{y}_\tau = k_1 c_0 e^{(\mu + 0.5(1-\alpha)\sigma^2)\tau} = k_1 c_0 e^{g\tau}. \tag{28}$$

Observe that, seen from date 0, generational welfare is increasing or decreasing with the time of birth depending upon whether the certainty-equivalent (or risk-adjusted) growth rate of consumption $g = \mu + 0.5(1-\alpha)\sigma^2$ is positive or negative.

We are considering a marginal investment project that reduces everyone's consumption living at date 0 by $\varepsilon > 0$ and which increases everyone's consumption living at date t by $B_t\varepsilon = c_t^\beta \varepsilon$. Parameter β measures the income-elasticity of the net benefit of the project. All people living at date 0, together with all generations born between date 1 and t will be affected by this investment decision. Let $\overline{y}_0(\varepsilon)$ denote the constant-equivalent consumption of the people living at date 0 as a function of the size ε of the investment. We have that

$$\frac{(\overline{y}_0(\varepsilon))^{1-\alpha}}{(1-p\delta)} = E_0\left[(c_0-\varepsilon)^{1-\alpha} + ... + (p\delta)^t (c_t + c_t^\beta \varepsilon)^{1-\alpha} + ...\right]. \tag{29}$$

In the right-hand side of this equality, we only represented the two terms involving ε in this infinite sum. Of course, $\overline{y}_0(0) = \overline{y}_0$ as defined by equation (28). We also have that

$$\overline{y}_0'(0) = (1-p\delta)k_1^\alpha \left((p\delta)^t c_0^\beta e^{((\beta-\alpha)\mu + 0.5(\beta-\alpha)^2\sigma^2)t} - 1\right) = k_2\left((p\delta)^t c_0^\beta e^{((\beta-\alpha)\mu + 0.5(\beta-\alpha)^2\sigma^2)t} - 1\right). \tag{30}$$

Similarly, let $\overline{y}_\tau(\varepsilon)$ denote the certainty-equivalent constant consumption of generation born at date τ as a function of the size ε of the investment. For all $\tau \in \{1, ..., t\}$, we have that

$$\overline{y}_\tau'(0) = k_2 (p\delta)^{t-\tau} c_0^\beta e^{((\beta-\alpha)\mu + 0.5(\beta-\alpha)^2\sigma^2)t} e^{\alpha g \tau}. \tag{31}$$

At date 0, the intergenerational welfare $W_0(\varepsilon)$ of the impacted generations is the sum of their lifetime utility $u(\overline{y}_\tau(\varepsilon); min(\overline{y}_0, \overline{y}_\tau))$ weighted by their size, where $\overline{y}_\ell$ is the smaller certainty-equivalent consumption levels among the present and future generations, viewed from date 0. From equation (28), we have that

$$min(\overline{y}_0, \overline{y}_\tau) = \begin{cases} \overline{y}_0, & \text{if } g \geq 0 \\ \overline{y}_\tau, & \text{if } g < 0, \end{cases} \tag{32}$$

where $g = \mu + 0.5(1-\alpha)\sigma^2$ is the certainty-equivalent growth rate of consumption. Let us first assume that g is positive. Then, we have that

$$W_0(\varepsilon) = u(\overline{y}_0(\varepsilon);\overline{y}_0) + (1-p)\sum_{\tau=1}^{t} u(\overline{y}_\tau(\varepsilon);\overline{y}_0). \tag{33}$$

Notice that this intergenerational welfare function does not penalize future generations with a collective pure preference for the present. Fully differentiating the above equation with respect to ε, and evaluating it at $\varepsilon = 0$, yields

$$\begin{aligned} W_0'(0) &= \eta\overline{y}_0^{-\gamma}\overline{y}_0'(0) + (1-p)\sum_{\tau=1}^{t}\overline{y}_\tau^{-\gamma}\overline{y}_\tau'(0) \\ &= \eta(k_1c_0)^{-\gamma}k_2\left((p\delta)^t c_0^\beta e^{((\beta-\alpha)\mu+0.5(\beta-\alpha)^2\sigma^2)t} - 1\right) \qquad (34) \\ &\quad +(1-p)\sum_{\tau=1}^{t}(k_1c_0)^{-\gamma}k_2(p\delta)^{t-\tau}c_0^\beta e^{(\alpha-\gamma)g\tau+(\beta-\alpha)\mu t+0.5(\beta-\alpha)^2\sigma^2 t} \geq 0 \qquad (35) \end{aligned}$$

Thus, intergenerational welfare is increased if and only if

$$1 \leq c_0^\beta(p\delta)^t e^{((\beta-\alpha)\mu+0.5(\beta-\alpha)^2\sigma^2)t}\left(1-\frac{(1-p)}{\eta}\frac{1-h^t}{1-h^{-1}}\right), \tag{36}$$

with $h = \exp((\alpha-\gamma)g)/(p\delta)$. Since the expected benefit at time t is equal to $E[B_t] = c_0^\beta\exp(\beta\mu t + 0.5\beta^2\sigma^2 t)$, This can be rewritten as follows:

$$1 \leq (p\delta)^t e^{(-\alpha\mu+0.5\alpha^2\sigma^2-\beta\alpha\sigma^2)t}\left(1-\frac{1-p}{\eta}\frac{1-h^t}{1-h^{-1}}\right)E[B_t]. \tag{37}$$

This optimality condition is classically characterized by requiring that the unit marginal cost is smaller than the present value of the future expected benefit discounted at a risk-adjusted rate ρ_t:

$$1 \leq e^{-\rho_t^{ante}t}E[B_t].$$

Comparing this to the above optimality condition yields proposition 3. ■

Appendix B: Proof of Proposition 4

We first measure ex post, i.e., at the birth date, the impact of the same marginal investment project as in the previous section on the generational constant-equivalent consumption level $y_\tau(\varepsilon)$ given by equation (14). For generation 0, we have that

$$y_0'(0) = k_2\left((p\delta)^t c_0^\beta e^{((\beta-\alpha)\mu+0.5(\beta-\alpha)^2\sigma^2)t} - 1\right). \tag{38}$$

Similarly, conditional to c_τ, at the margin, the impact of the investment ε on generation τ's welfare equals

$$y'_\tau(0) = k_2(p\delta)^{t-\tau} c_\tau^\beta e^{((\beta-\alpha)\mu+0.5(\beta-\alpha)^2\sigma^2)(t-\tau)}. \tag{39}$$

The impact of this generational benefit of the marginal investment is valued at date 0 by using the FOIA price kernel m_τ, with

$$m_\tau = \begin{cases} \left(\frac{y_\tau}{y_0}\right)^{-\gamma}, & \text{if } y_\tau < y_0 \\ \eta^{-1}\left(\frac{y_\tau}{y_0}\right)^{-\gamma}, & \text{if } y_\tau \geq y_0, \end{cases} \tag{40}$$

It implies that the present value of the impact of the marginal investment on generation τ's welfare, $\tau > 0$, equals

$$\begin{aligned} v_\tau &= E_0[m_\tau y'_\tau(0)] \\ &= k_2(p\delta)^{t-\tau} c_0^\gamma e^{((\beta-\alpha)\mu+0.5(\beta-\alpha)^2\sigma^2)(t-\tau)} \left(\int_{-\infty}^{0} e^{(\beta-\gamma)x} dF_\tau(x) + \eta^{-1} \int_0^{+\infty} e^{(\beta-\gamma)x} dF_\tau(x) \right) \end{aligned}$$

where F_τ is the CDF of the normally distributed random variable with mean μt and variance $\sigma^2 t$.

LEMMA 1. *Suppose that z is normally distributed with mean m and standard deviation s. Then, for any set $Z \subset \mathcal{R}$ and any $k \in \mathcal{R}$, we have that*

$$\int_{z\subset Z} \exp(kz) dF(z) = \exp(km + 0.5k^2 s^2) P\left[\hat{z} \subset Z \mid \hat{z} \sim N(m + ks^2, s^2)\right],$$

where F is the CDF of $z \sim N(m, s^2)$.

Proof: This lemma is proven as follows:

$$\begin{aligned} \int_{z\subset Z} \exp(kz) dF(z) &= \frac{1}{\sqrt{2\pi}s} \int_{z\subset Z} \exp(kz) \exp\left(-\frac{(z-m)^2}{2s^2}\right) dz \\ &= \frac{1}{\sqrt{2\pi}s} \int_{z\subset Z} \exp(km + 0.5k^2 s^2) \exp\left(-\frac{(z-(m+ks^2))^2}{2s^2}\right) dz \\ &= \exp(km + 0.5k^2 s^2) P\left[\hat{z} \subset Z \mid \hat{z} \sim N(m + ks^2, s^2)\right] \blacksquare \end{aligned}$$

Using the lemma, v_τ simplifies to

$$v_\tau = k_2(p\delta)^{t-\tau} e^{f_\tau} \left(q_\tau + \eta^{-1}(1 - q_\tau)\right) E_0[B_t],$$

with

$$f_\tau = \left(-\alpha\mu + \frac{1}{2}\alpha^2\sigma^2 - \beta\alpha\sigma^2\right) t - \left((\gamma-\alpha)\mu + \frac{1}{2}(\gamma^2-\alpha^2)\sigma^2 - \beta(\gamma-\alpha)\sigma^2\right)\tau$$

and

$$q_\tau = P\left[z \leq -\frac{\mu + (\beta-\gamma)\sigma^2}{\sigma}\sqrt{\tau} \mid z \sim N[0,1]\right] \tag{41}$$

for all $\tau \geq 1$. In particular, when σ tends to zero, q_τ is either 0 or 1 respectively when μ is positive or negative.

The marginal investment increases intergenerational welfare if and only if

$$0 \leq y_0'(0) + (1-p)\sum_{\tau=1}^{t} v_\tau$$

$$= -k_2 + k_2(p\delta)^t e^{f_0} E_0[B_t] + k_2(1-p)\sum_{\tau=1}^{t}(p\delta)^{t-\tau} e^{f_\tau}\left(q_\tau + \eta^{-1}(1-q_\tau)\right) E_0[B_t].$$

This is equivalent to the following standard NPV condition:

$$1 \leq e^{-\rho_t^{post} t} E_0[B_t],$$

where the risk-adjusted discount rate ρ_t^{post} is defined characterized in Proposition 4. ■

Appendix C: Proof of equation (26)

Suppose first that r_α is smaller than r_γ. Because η is larger than 1, $q_\tau + \eta^{-1}(1-q_\tau)$ is always smaller than unity. It implies that

$$\sum_{\tau=1}^{t} e^{(r_\alpha - r\gamma)\tau}(q_\tau + \eta^{-1}(1-q_\tau)) \leq \sum_{\tau=1}^{t} e^{(r_\alpha - r\gamma)\tau} \leq \frac{1}{e^{r_\gamma - r_\alpha} - 1}, \tag{42}$$

which is finite. This implies that the log in the right-hand side of equation (22) is bounded above, proving that ρ_t^{ante} tends to r_α when t tends to infinity and $r_\alpha \leq r_\gamma$.

Suppose alternatively that r_α is larger than r_γ. We hereafter use a continuous-time version of this equation in order to apply standard differential calculus. It is written as follows:

$$\rho_t^{post} = r_\alpha - \frac{1}{t}\ln\left(1 + (1-p)\int_0^t e^{(r_\alpha - r_\gamma)\tau}\left(q_\tau + \eta^{-1}(1-q_\tau)\right)d\tau\right). \tag{43}$$

The fact that r_α is larger than r_γ implies that the log in the right-hand side of this equation is unbounded. Using the L'Hospital rule twice yields

$$\rho_\infty^{post} = r_\alpha - \lim_{t\to\infty} \frac{(1-p)e^{(r_\alpha - r_\gamma)t}(q_t + \eta^{-1}(1-q_t))}{1 + (1-p)\int_0^t e^{(r_\alpha - r_\gamma)\tau}(q_\tau + \eta^{-1}(1-q_\tau))d\tau} \tag{44}$$

$$= r_\alpha - (r_\alpha - r_\gamma)\lim_{t\to\infty} \frac{(1-p)e^{(r_\alpha - r_\gamma)t}(q_t + \eta^{-1}(1-q_t))}{(1-p)e^{(r_\alpha - r_\gamma)t}(q_t + \eta^{-1}(1-q_t))}. \tag{45}$$

This second equality comes from the observation that q_t tends asymptotically to zero or one, so that $\partial q_t/\partial t = 0$ asymptotically. The above equation implies that ρ_t^{post} tends to r_γ in that case. ■

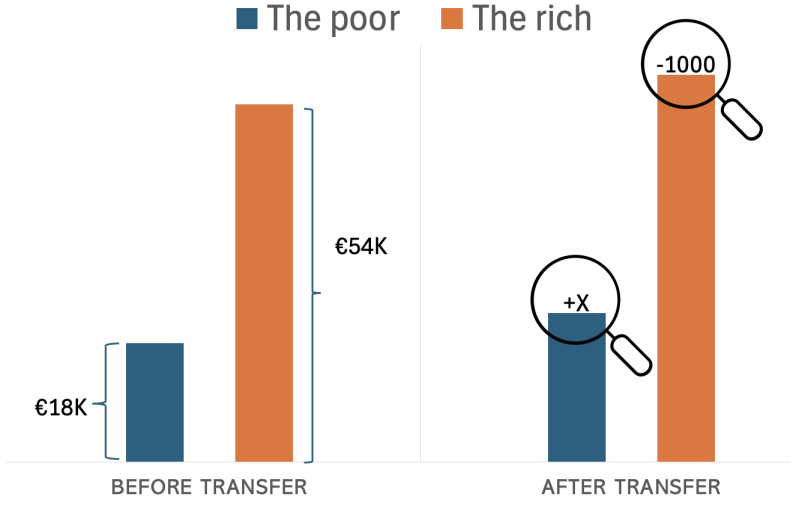
APPENDIX D: INSTRUCTIONS

D.1 *The leaky bucket question*

Imagine living in a society made up of **two social classes with equal populations**, where the wealthy class earns **three times** the after-tax annual income of the poor class. The poor class earns an after-tax income of **€18,000**, while the wealthy class earns an after-tax income of **€54,000**.

Now, consider a policy that redistributes wealth from the wealthy class to the poor class. While this may reduce the wealth gap, it could also lead to significant inefficiencies, resulting in an overall decrease in societal wealth.

More specifically, each year, €1,000 are taken from the wealthy and X € are redistributed to the poor, with the remainder, i.e., (1,000 - X) €, being lost.



For the different values of X below, ranging from 1,000 to 100 in increments of 100, please indicate whether you support such transfers:

1. If 1,000 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
2. If 900 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
3. If 800 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
4. If 700 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No

5. If 600 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
6. If 500 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
7. If 400 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
8. If 300 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
9. If 200 € can actually be transferred to the poor, do you support such transfers?
   ☐ Yes ☐ No
10. If 100 € can actually be transferred to the poor, do you support such transfers?
    ☐ Yes ☐ No

[Next Page]

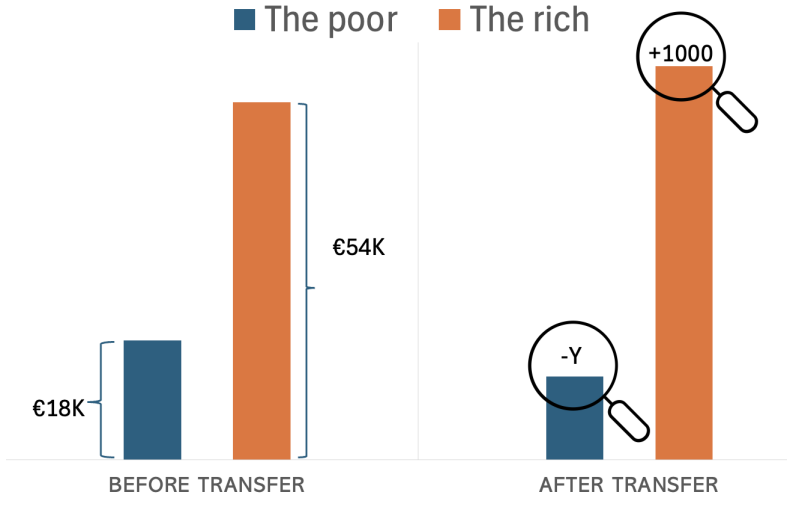
11. What is the minimum amount (in euros) that must be distributed to the poor for you to support this €1,000 tax on the wealthy? Please provide an exact number.
    _____
12. Could you please explain how you made the choices above in the described scenario?
    _____

D.2 *The productive pipeline question*

Imagine living in a society made up of **two social classes with equal populations**, where the wealthy class earns **three times** the after-tax annual income of the poor class. The poor class earns an after-tax income of **€18,000**, while the wealthy class earns an after-tax income of **€54,000**.

Now, consider a policy that increases total income but at the expense of the poor. This could be, for example, a reduction in taxes.

More specifically, each year, for every €1,000 of additional income generated for the wealthy, an amount of Y € is lost for the poor.



For different values of Y below, ranging from 100 to 1,000 in increments of 100, please indicate whether you support such transfers:

1. If the policy reduces the income of the poor class by €100, do you support such transfers?
   ☐ Yes ☐ No
2. If the policy reduces the income of the poor class by €200, do you support such transfers?
   ☐ Yes ☐ No
3. If the policy reduces the income of the poor class by €300, do you support such transfers?
   ☐ Yes ☐ No
4. If the policy reduces the income of the poor class by €400, do you support such transfers?
   ☐ Yes ☐ No

5. If the policy reduces the income of the poor class by €500, do you support such transfers?
   ☐ Yes ☐ No

6. If the policy reduces the income of the poor class by €600, do you support such transfers?
   ☐ Yes ☐ No

7. If the policy reduces the income of the poor class by €700, do you support such transfers?
   ☐ Yes ☐ No

8. If the policy reduces the income of the poor class by €800, do you support such transfers?
   ☐ Yes ☐ No

9. If the policy reduces the income of the poor class by €900, do you support such transfers?
   ☐ Yes ☐ No

10. If the policy reduces the income of the poor class by €1,000, do you support such transfers?
    ☐ Yes ☐ No

    [Next Page]

11. What is the maximum reduction in income (in euros) for the poor class that would still allow you to support such transfers? Please provide an exact number.

    _____

12. Could you please explain how you made the choices above in the described scenario?

    _____

D.3 *The risk-reducing question*

Imagine that you are offered to participate in lottery **L0**, where you can win **€54,000** or **€18,000** with equal probabilities.

You are now offered to **modify these potential gains by a partial transfer in order to reduce the gap between them. Unfortunately, this may reduce the expected value of the lottery.**

Please indicate, for each lottery after transfer, **L1**, described below, whether you prefer it to the initial lottery **L0**.

1. The lottery after transfer, L1, gives outcomes of €53,000 or €19,000 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

2. The lottery after transfer, L1, gives outcomes of €53,000 or €18,900 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

3. The lottery after transfer, L1, gives outcomes of €53,000 or €18,800 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

4. The lottery after transfer, L1, gives outcomes of €53,000 or €18,700 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

5. The lottery after transfer, L1, gives outcomes of €53,000 or €18,600 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

6. The lottery after transfer, L1, gives outcomes of €53,000 or €18,500 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

7. The lottery after transfer, L1, gives outcomes of €53,000 or €18,400 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

8. The lottery after transfer, L1, gives outcomes of €53,000 or €18,300 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

9. The lottery after transfer, L1, gives outcomes of €53,000 or €18,200 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0

10. The lottery after transfer, L1, gives outcomes of €53,000 or €18,100 with equal probabilities. Which lottery do you prefer?
    ☐ L1 ☐ L0

    [Next Page]

11. The lottery after transfer, L1, gives outcomes of €53,000 or €18,000 plus X euros, with equal probabilities. What is the minimum amount (in euros) for X such that you prefer L1 over L0?

    _____

D.4 *The risk-taking question*

Imagine that you are offered to participate in a lottery **L0** in which you will win either €54,000 or €18,000 with equal probabilities.

Now you are offered to **modify these potential gains through a partial transfer in order to increase the expected value of the lottery. Unfortunately, this may also increase the spread between the outcomes of the lottery.**

Please indicate, for each lottery after transfer, **L1**, described below, whether you prefer it to the initial lottery **L0**.

1. The lottery after transfer, L1, gives payoffs of €55,000 or €17,900 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
2. L1 gives payoffs of €55,000 or €17,800 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
3. L1 gives payoffs of €55,000 or €17,700 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
4. L1 gives payoffs of €55,000 or €17,600 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
5. L1 gives payoffs of €55,000 or €17,500 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
6. L1 gives payoffs of €55,000 or €17,400 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
7. L1 gives payoffs of €55,000 or €17,300 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
8. L1 gives payoffs of €55,000 or €17,200 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
9. L1 gives payoffs of €55,000 or €17,100 with equal probabilities. Which lottery do you prefer?
   ☐ L1 ☐ L0
10. L1 gives payoffs of €55,000 or €17,000 with equal probabilities. Which lottery do you prefer?
    ☐ L1 ☐ L0

11. After the transfer, lottery L1 gives payoffs of €55,000 or €18,000 $-X$, with equal probabilities. What is the maximum amount (in euros) for X such that you prefer L1 to L0?

_____

APPENDIX E: TABLES AND FIGURES

Gender	Survey Sample	Population 18+ (2024)
Male	1,492 (49.57%)	47.57%
Female	1,518 (50.43%)	52.43%

Table E.1. Gender Distribution of Survey Sample and Population (2024)

Age Group	Survey Sample	Population 18+ (2024)
18-24	236 (7.78%)	7.55%
25-34	422 (14.02%)	14.89%
35-49	736 (24.45%)	24.25%
50-64	796 (26.45%)	25.22%
65+	820 (27.24%)	28.08%

Table E.2. Age Distribution of Survey Sample and Population (2024)

Region	Survey Sample	Population (2024)
Uda1 (Île-de-France)	562 (18.67%)	18.88%
Uda2 (Pays de la Loire, Normandie, Bretagne, Centre-Val de Loire)	679 (22.56%)	20.19%
Uda3 (Bourgogne-Franche-Comté, Hauts-de-France, Grand Est)	633 (21.03%)	21.80%
Uda4 (Occitanie, Nouvelle-Aquitaine)	511 (16.98%)	18.71%
Uda5 (Auvergne-Rhône-Alpes, Provence-Alpes-Côte d'Azur)	625 (20.76%)	20.42%

Table E.3. Regional Distribution of Survey Sample and Population (2024)

CSP (Socio-professional category)	Survey Sample	Population (2024)
CSP+ (Executives and higher intellectual professions)	400 (13.29%)	12.31%
CSP- (Intermediate professions, employees, workers)	1225 (40.70%)	38.53%
Other Active (Farmers, craftsmen, traders, etc.)	25 (0.83%)	5.18%
Inactive (People outside the workforce, retirees, students, etc.)	1,360 (45.18%)	42.99%

Table E.4. CSP Distribution of Survey Sample and Population (2024)

0.008426966 0.014446228 0.008025682 [8] 0.005617978 0.003210273 0.004414125 0.020064205

Values	Percentage (x)	Percentage (y)
0	53.17	84.11
100	1.81	5.94
200	3.17	2.29
300	2.61	1.24
400	5.90	0.84
500	9.71	1.44
600	3.77	0.80
700	4.53	0.56
800	4.70	0.32
900	7.78	0.
1000	2.85	2.01

Table E.5. Distributions of x and y in the social allocation tasks

References

Abdellaoui, Mohammed, Han Bleichrodt, Olivier L'Haridon and Dennie van Dolder. 2016. "Measuring Loss Aversion under Ambiguity: A Method to Make Prospect Theory Completely Observable." *Journal of Risk and Uncertainty* 52(1):1–20. [13]

Amiel, Y. and F. Cowell. 1999. *Thinking about inequality*. Cambridge University Press. [2, 4, 13]

Arrow, K.J. 1973. "Rawls's Principle of Just Saving." *The Swedish Journal of Economics* 75:323–335. [2, 15]

Bansal, R. and A. Yaron. 2004. "Risks For the Long Run: A Potential Resolution of Asset Pricing Puzzles." *Journal of Finance* 59:1481–1509. [19]

Barro, R.J. 2006. "Rare Disasters and Asset Markets in the Twentieth Century." *Journal of Finance* 121:823–866. [19]

Barro, R.J. 2009. "Rare disasters, asset prices, and welfare costs." *American Economic Review* 99(1):243–264. [19]

Barsky, Robert B., F. Thomas Juster, Miles S. Kimball and Matthew D. Shapiro. 1997. "Preference Parameters and Behavioral Heterogeneity: An Experimental Approach in the Health and Retirement Study." *The Quarterly Journal of Economics* 112(2):537–579. [10]

Blanchard, Olivier J. 1985. "Debt, Deficits, and Finite Horizons." *Journal of Political Economy* 93(2):223–247.
URL: *https://ideas.repec.org/a/ucp/jpolec/v93y1985i2p223-47.html* [4, 15]

Christensen, P., K. Gillingham and W. Nordhaus. 2018. "Uncertainty in forecasts of long-run economic growth." *Proceedings of the National Academy of Sciences* 115(21):5409–5414. [19]

Collin-Dufresne, P., M. Johannes and L.A. Lochstoer. 2016. "Parameter learning in general equilibrium: The asset pricing implications." *American Economic Review* 106:664–698. [19]

Dasgupta, Partha. 2007. "The Stern Review's economics of climate change." *National Institute Economic Review* (199):4–7. [4]

Douenne, Thomas and Adrien Fabre. 2022. "Yellow vests, pessimistic beliefs, and carbon tax aversion." *American Economic Journal: Economic Policy* 14(1):81–110. [6]

Drupp, Moritz A., Mark C. Freeman, Ben Groom and Frikk Nesje. 2018. "Discounting Disentangled." *American Economic Journal: Economic Policy* 10(4):109–34. [4]

Epstein, L. and S. Zin. 1989. "Substitution, risk aversion and the temporal behavior of consumption and asset returns: A theoretical framework." *Econometrica* 57:937–969. [19]

Epstein, L. and S. Zin. 1991. "Substitution, risk aversion and the temporal behavior of consumption and asset returns: An empirical analysis." *Journal of Political Economy* 99:263–286. [19]

Frederick, Shane, George Loewenstein and Ted O'donoghue. 2002. "Time discounting and time preference: A critical review." *Journal of Economic Literature* 40(2):351–401. []

Gollier, C. 2016. "Evaluation of long-dated assets: The role of parameter uncertainty." *Journal of Monetary Economics* 84:66–83. [19]

Gollier, C. 2018. "Stochastic volatility implies fourth-degree risk dominance: Applications to asset pricing." *Journal of Economic Dynamics and Control* 95:155–171. [19]

Gollier, C. and J.K. Hammitt. 2014. "The Long-Run Discount Rate Controversy." *Annual Review of Resource Economics* 6(1):273–295. []

Kahneman, Daniel and Amos Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47(2):263–291. [3, 13]

Okun, A. M. 1975. *Equality and efficiency: The big tradeoff.* Brookings Institution Press. [2]

Pirttila, J. and R. Uusitalo. 2010. "A 'Leaky Bucket' in the Real World: Estimating Inequality Aversion using Survey Data." *Economica* 77(305):60–76. [2, 4, 13]

Pratt, J.W. 1964. "Risk aversion in the small and in the large." *Econometrica* 32(1/2):122–136. [12]

Ramsey, F.P. 1928. "A mathematical theory of savings." *The Economic Journal* 38:543–559. [4]

Rawls, J. 1971. *A theory of justice.* Harvard University Press. [2, 3, 5, 12]

Segal, U. and A. Spivak. 1990. "First order versus second order risk aversion." *Journal of Economic Theory* 51(1):111–125. [3, 12]

Stern, N. 2007. *The Economics of Climate Change: The Stern Review.* Cambridge University Press. [4, 19]

Weil, P. 1989. "The equity premium puzzle and the risk-free rate puzzle." *Journal of Monetary Economics* 24:401–421. [19]

Yaari, M.E. 1965. "Uncertain Lifetime, Life Insurance and the Theory of the Consumer." *Review of Economic Studies* 32:137–150. [4, 15]