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The behavioural economics of climate change

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Abstract This paper attempts to bring some central insights from behavioural economics into the economics of climate change. In particular, it discusses (i) implications of prospect theory, the equity premium puzzle, and time-inconsistent preferences in the choice of discount rate used in climate-change cost assessments, and (ii) the implications of various kinds of social preferences for the outcome of climate negotiations. Several reasons are presented for why it appears advisable to choose a substantially lower social discount rate than the average return on investments. It also seems likely that taking social preferences into account increases the possibilities of obtaining international agreements, compared to the standard model. However, there are also effects going in the opposite direction, and the importance of sanctions is emphasized.

Key words: behavioural economics, prospect theory, equity premium puzzle, social preferences, climate negotiations

JEL classification: D63, Q54

I. Introduction

The effects of climate change and their remedies are frequently discussed both in the media and among politicians and the general public. Interest in the problems at hand has increased steadily in the last few years, and today the issue is very high on the political agenda worldwide; large initiatives have been and will be taken to handle the problem effectively.

Within economic science we have, parallel to this development, witnessed a dramatically increased interest in behavioural economics (BE) in the last decade or so. First, compared to conventional economic theory, BE emphasizes the notion that people have cognitive limitations, and that, at least partly for this reason, they sometimes make seemingly irrational decisions. There is, in particular, much empirical evidence with respect to choices under risk

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and over time. Second, much work in BE follows Adam Smith (Evensky, 2005; Ashraf *et al*., 2005), in particular *The Theory of Moral Sentiments*, but also *The Wealth of Nations*, in emphasizing the idea that people's behaviour is not solely motivated by their own material pay-offs, and that issues such as perceived fairness and social norms often influence human decisions to a large extent. Third, again contrary to conventional economic theory but following Adam Smith, BE often highlights the notion that we act in a social context, and that issues such as social approval and status are central motivators of human behaviour.

Crucial issues in the economics of climate change concern how to deal with long-run choices over time, as well as problems under risk, i.e. issues where BE has identified that conventional theory may provide poor predictions of human behaviour. Although the uncertainty regarding the consequences of climate change appears to have decreased somewhat lately, since most researchers now at least agree that the changes in the climate that are starting to appear are, indeed, largely due to human activity, the overall extent of the changes and their distributional impact are still highly uncertain. Moreover, how people deal with choices under risk has important implications for the discussion of the appropriate discount rate, an issue that is of crucial importance in the economics of climate change.

Given this, it is surprising that BE has had so little influence on the economics of climate change so far. The aim of this paper is a modest attempt to do just this: bring central insights from BE into the economics of climate change. Section II deals with the crucial issue of discounting in a world where people are not time-consistent expected-utility maximizers, whereas section III looks into the issue of human cooperation in general, and implications for climate negotiations in particular. Section IV provides some concluding remarks.

II. Discounting, risk, and time

One of the major discussions in the literature on climate policy is the choice of discount rates. The discount rate may be determined from both the consumption and production sides of the economy. From the consumption perspective, the interest rate reflects the marginal rate of substitution between consumption now and next year, and follows from the parameters in the utility function as given by the Ramsey rule

$$r = \rho + g\sigma$$

This equation states that the rate of return should equal the pure time discount rate, ρ, plus the changes in marginal utility over time, determined by the consumption growth rate, g, and the intertemporal elasticity of substitution ($1/\sigma$). One of the most controversial features of the Stern (2007) report concerns the choices of these parameters ($\rho = 0.1\%$, $g = 1.3\%$, $\sigma = 1$), which yield an annual interest rate of 1.4 per cent.

The parameters of the Ramsey rule may be estimated from market data or evaluated based on ethical considerations. For example, Dasgupta (forthcoming) argues that the implied weight on redistribution between rich future generations and the poorer current generation is unreasonably low. Alternatively, one may compare the result, r, with estimates from the production side, e.g. market data on return on investment. Nordhaus (2007) criticizes the choice in the Stern report on the grounds that the market real return on investment is about 6 per cent per year.

A problem with the latter approach is that there are so many rates of return, and they vary much more than we are able to explain. For example, Mehra and Prescott (2003) report the return on relatively riskless securities (treasury bills) and stock-market indices for different periods, datasets, and countries. For the USA in the period 1926–2000, where the best data are available, the mean risk-free return is 0.4 per cent, while the mean return on stocks is 8.8 per cent, i.e. an 8.4 percentage point difference—the equity premium. It should be noted that many estimates of the premium are less dramatic, but still considerable.[1] So why compare the 1.4 per cent with the return on investment and not with the risk-free rate of return?

To answer this question we need to know why the equity premium is so large. For a long time, the standard answer used to be risk aversion, with the theoretical justification from the capital asset pricing model (CAPM) (Sharpe, 1964; Lintner, 1965; Mossin, 1966). One of the main insights of the CAPM is that the risk associated with an asset is not the variance of the asset return. A well-diversified investor will own many assets, and in contemplating whether to buy a particular asset, the crucial risk question is not the variance of the asset in question but rather how the overall portfolio risk is affected. It then turns out that the relevant measure of risk is the covariance with the market portfolio, since that is the portfolio that well-diversified investors will hold. An asset that does not add to the overall risk is, from a well-diversified investor's perspective, equivalent to a risk-free asset, and the required rate of return should then equal the risk-free rate (0.4 per cent with the numbers above). An asset that reduces the risk of the portfolio is even better; now the required rate of return is less than the risk-free interest rate, and may even be negative. However, the average asset is perfectly correlated with the market portfolio and should therefore have a return equal to the market portfolio, i.e. 8–9 per cent.

The same logic applies for climate change; if we invest in reduced carbon-dioxide (CO_2) emissions, how will this affect the overall risk in the society? The answer depends on how climate damages are expected to co-vary with future consumption, which is far from self-evident. Consider first the case where future damage is simply proportional to economic activity (and where climate damage decreases with abatement investments). Then the return to climate investment will correlate perfectly with the market portfolio, and there will be no reason to have different discount rates for abatement and other investments. This is consistent with Nordhaus (2007), who assumes that climatic investments share the risk properties of other capital investments.

Weitzman (2007*b*, pp. 713–14), on the other hand, uses a model with several sectors and argues that climate damage affects only a minor sector, the 'outdoors', and hence argues for a lower but still positive correlation. The resulting discount rate would then be larger than the risk-free rate but lower than the mean return on stocks. However, we think it is important to consider different kinds of risks and, more specifically, that climate investments presumably reduce the risk and severity of natural catastrophes in terms of, for example, hurricanes or drought. Since the reduction of a catastrophe would be larger for larger catastrophes, we may obtain a negative correlation between the outcomes of abatement investment and the rest of the economy. Consider the extreme alternatives of complete abatement with no man-made climate change and business as usual with no abatement. Then the question of correlations corresponds to whether the future consumption is less or more uncertain with man-made

[1] In Merha and Prescott's (2003) survey, the highest risk-free rate is 3.2 per cent for Germany, 1978–97, and the lowest equity premium is 3.3 per cent for Japan, 1970–99. Dimson *et al*. (2007) argue that the premium tends to be overestimated, but that the puzzle nevertheless remains.

climate change. Less uncertainty with no potential climate change corresponds to returns to abatement being negatively correlated with future consumption. Whether the overall discount rate for climate change should be larger or smaller than the risk-free rate will then depend on the relative size of these components; see also Howarth (2003) who conducts a simple simulation yielding zero correlation. In this perspective, the interest rates in the Stern (2007) report are not obviously low.

However, a problem here is that the CAPM account of the equity premium is hardly plausible in the first place. Transferring wealth from bonds to equity increases both the return on a portfolio and the associated risk, but, as demonstrated by Mehra and Prescott (1985), the difference in return is simply too high to be explained only by risk aversion—the equity premium puzzle. They argue that, based on reasonable parameter assumptions, CAPM can explain less than one percentage point of the equity premium. Since their seminal paper, many attempts have been made to explain the puzzle, but reviews such as Kocherlakota (1996) and Mehra and Prescott (2003) conclude that we still lack a good explanation. It is worth noting that each of the possible explanations would have implications for the choice of discount rate for climate policy. In most cases these implications are not explicitly analysed. One exception is a recent cut at the problem by Weitzman (2007*a*) who argues that, since we do not know the distribution of asset return but have to estimate it, the tail tends to fatten and the perceived risk increases—to the extent that it becomes unclear why anyone saves in risky assets at all. Weitzman (2007*b*) then argues that if this account of the puzzle is correct, the implications for climate policy are far more dramatic than the Stern review suggests. The reason is similar to why CAPM may suggest a discount rate below the risk-free rate: continued large greenhouse-gas emissions constitute a gamble as the future consequences are not known, and if Weitzman's argument is correct, then the reason for avoiding the gamble is much stronger than in conventional models.

Here we will only discuss one of the possible explanations of the equity premium puzzle in some detail; it is one derived from BE and is the one that we consider to be the most plausible.[2] Benartzi and Thaler (1995) explain the equity premium using Kahneman and Tversky's (1979) prospect theory (PT). According to the review in Starmer (2000), cumulative PT is the theory that best predicts the data we have on choices under uncertainty, so it is a natural candidate to explain also the effect of uncertainty on the return on financial instruments. One of the main elements of PT is the concept of loss aversion, where it is argued that losses are valued much more highly than gains (typically more than twice as high). A highly stylized representation[3] of this theory is to assume that individuals maximize the expected value of the value-function $v(x)$ where

$$v(x) = \begin{cases} x & \text{for } x > 0 \\ 2.25x & \text{for } x < 0 \end{cases}.$$

This introduces a kink in the value function around the *status quo*. At the kink the slope makes a discrete jump, so that local 'risk aversion' is infinite. In expected utility theory, the utility function has no similar kink, hence it is almost linear for sufficiently small variation,

[2] We do not suggest that all other explanations are wrong. Indeed, we consider it likely that several contribute to our understanding, albeit to different extents.

[3] This formulation disregards two important elements of prospect theory. First, people are assumed to be risk-averse for gains and risk-seeking for losses. With the calibrated version used in Benartzi and Thaler (1995), these effects are weak. Second, people are assumed effectively to overestimate low probabilities and underestimate large ones. This is disregarded in Benartzi and Thaler's analysis.

implying risk neutrality for small gambles (Rabin, 2000; Rabin and Thaler, 2001). Consider, for example, a gamble with equal probability of $-Z$ and $+2Z$. With the PT preferences above, this gamble will be turned down irrespective of Z, while a risk-averse expected-utility maximizer will accept if Z is small but may reject if Z is sufficiently large. One way to think about the failure of expected utility theory (EU) to explain the equity premium is that holding assets involves too small gambles.

Another major difference between EU and PT is how they view repeated gambles. Samuelson (1963) points out that if a gamble is turned down once (at any level of wealth), then expected utility implies that n repetitions of the same gamble should be turned down, too. If the subject does not watch as each gamble is played out, PT on the other hand allows the subject to turn down the single gamble but accept the repeated one. The intuition is that the main risk aversion in PT is due to the kink in the value function, and that the accumulated pay-off in the repeated gamble will move away from the kink. Thus, risk aversion is much lower for repeated gambles.

Now, what has all this got to do with the equity premium? The point is that the stock market can also be seen as a series of gambles. Each day, even each minute, may be seen as a lottery when you own stocks. PT predicts very high risk aversion toward small lotteries, so if each day is seen as a separate lottery, the PT individual will turn down the lottery. But as the lotteries are repeated they become increasingly attractive to the PT individual. It turns out that if each year in the asset market is seen as one lottery, then that generates exactly the amount of risk aversion needed to explain the equity premium. The reference point must thus move once a year; not once a month or once per quarter, and not once every second year. While this may, of course, be questioned, Benartzi and Thaler (1995) argue that resetting the reference point every twelfth month is plausible, as investors have to file their tax reports yearly. There is some experimental support for the Benartzi and Thaler explanation: Gneezy and Potters (1997) and Gneezy *et al*. (2003) find that investors are indeed more risk averse when evaluation periods are experimentally manipulated to be more frequent, and Eriksen and Kvaløy (2008) find similar results for investors managing other people's money, e.g. fund investors.

Now, if this is the true explanation for the equity premium puzzle,[4] then what is the appropriate discount rate for climate abatement projects? To assess climate risk according to PT we need to specify a reference point. What changes will be perceived as gains and losses? The canonical choice is to use the *status quo*. If the Maldives are flooded, it would be seen as a loss and not as an absence of a gain (the gain being the continued habitation of the Maldives). But if all changes are seen as losses, then the kink in the value function does not matter. With the value function above, we would be on the linear part of the value-function implying risk neutrality and, hence, a risk-free discount rate, even if climate investments do lower the society's overall risk.[5] This accounts for the equity premium puzzle and thus also indicates a discount rate close to the risk-free rate (see also Howarth, forthcoming).

[4] Recent alternative (partial or complete) explanations of the equity premium puzzle include: disasters with non-negligible probabilities (Barro, 2006), which is somewhat similar to the explanation by Weitzman (2007*a*) mentioned above; transaction costs (Jang *et al*., 2007); habit formation (Pijoan-Mas, 2007); and incomplete risk sharing among stockholders resulting from the combination of aggregate uncertainty, borrowing constraints, and idiosyncratic shocks (Gomes and Michaelides, 2008).

[5] Actually, the PT predicts that individuals are risk-seeking when it comes to losses. Hence the predicted required rate of return should be slightly higher than the risk-free rate, since we should like to increase risk when risk-seeking. The claimed convexity is, however, very weak and the effect should be very small.

Thus far we have only considered the use of market data to infer the correct interest rate. An alternative approach is to consider the parameters in the Ramsey equation directly. The central parameter is then the elasticity of intertemporal substitution (EIS), corresponding to $1/\sigma$ above. Vissing-Jørgensen (2002) finds that EIS differs between stock holders (0.3–0.4) and bond holders (0.8–1.0). With the parameters in Stern this amounts to interest rates in the 3.3–4.4 per cent range for stock holders and 1.4–1.7 per cent for bond holders. Similarly, Mehra and Prescott (1985) argue (without explicit statements about σ) that a direct assessment of r based on estimates of EIS should yield an interest rate of about 4–4.5 per cent.

The difference between the observed risk-free rate and the assessed risk-free rate based on EIS is itself a puzzle—the 'risk free rate puzzle' (Weil, 1989)—which is closely related to the equity premium puzzle. The literature has been somewhat more successful at explaining this puzzle, where habit formation and liquidity services of treasury bills are possible explanations. Again, the explanations of the puzzle have implications for the choice of discount rate. For example, if treasury bills provide liquidity services, then the direct EIS approach may provide a more reliable estimate of the risk-free return than the observed return on treasury bills.

As argued above, the question of discount rates in the assessment of climate abatement cannot be disentangled from the discussion of the equity premium puzzle. Here, BE offers one potential piece of the explanation, with important implications for the choice of discount rates.

(i) Self control and social discount rates

A separate question concerns the problems of self-control and the relationship between observed behaviour and the social optimum. Many people prefer \$10 today to \$11 tomorrow, but at the same time prefer \$11 paid on day 15 to \$10 paid on day 14. In other words, the discount rate is high in the very short run, but low in the long run. One possible account of this result is presented in Fudenberg and Levine (2006), extending an idea of Thaler and Sherfin (1981). The self is represented by a sequence of myopic 'doers' and one 'long-term planner'. The doers will rule the game unless the planner exerts an effort of self-control. The cost of making the doer deviate from the myopic optimum depends on the short-run cost of deviating. The current doer has no opinion about money paid out in the future; hence, it takes no self-control to make him choose \$11 over \$10. However, the current doer strongly prefers \$10 now to nothing now (and \$11 tomorrow). To make the doer choose \$11 tomorrow is thus costly in terms of self-control, and the cost may exceed the \$1 gain.

This model of choice is consistent with more recent literature showing that long-term considerations are given less weight under a high cognitive load. For example, Shiv and Fedorikhin (1999) found in an innovative experiment that the subjects were more likely to choose a cake over a fruit salad when they had to remember seven digits in order to get anything, while they chose the fruit salad when they only had to remember two digits. Presumably, the cognitive part of the brain (primarily the prefrontal cortex) realizes that fruit salad is better in the long run, but when this part of the brain—or the planner—is occupied, another part takes over.

Now, assume that we observe that subjects turn down a 10 per cent daily return. Should we then, respecting consumer sovereignty, use a 10 per cent daily discount rate? Or would the person be better off with \$11 tomorrow rather than \$10 today? Now suppose that the planner's true preferences amount to a zero pure time preference. In a situation where the cost of self-control is low, the subject will save at a 1 per cent yearly rate, while turning down a

10 per cent daily rate. For example, the person would happily choose a saving programme forcing him to save at a 1 per cent yearly return starting next year (avoiding the cost of controlling current doers). Similarly, the person would vote for a public project that is profitable at a 1 per cent discount rate.

Above, we have questioned the common claim that saving is lower than what a 0.1 per cent pure time preference would imply. Let us still, for the moment, accept that claim. There are then two possible interpretations of such a finding: saving is lower than the planner would have liked it to be, owing to the cost of self-control; or, the planner may have a pure rate of time preference above 0.1 per cent. Without further analysis we cannot rule out one in favour of the other.

Note finally that with multiple selves (the planner and many doers) the question arises: who represents the person's *true* preferences? Above, we have taken for granted that the planner is the one to listen to, but that is not obvious. Still, according to Harsanyi (1982, p. 55), whereas choices may be 'based on erroneous factual beliefs, or on careless logical analysis, or on strong emotions that at the moment greatly hinder rational choice', what he denotes 'true preferences' are the preferences that an individual would have had if 'he had all the relevant factual information, always reasoned with the greatest possible care, and were in a state of mind most conducive to rational choice'. He argues that it is the true preferences that carry moral significance, which would presumably correspond to the planner's preferences in our case. See also Karp (2005) for a recent analysis of global warming and hyperbolic discounting.

(ii) The ethics of discounting

One possible view of the Ramsey rule is to take an explicitly ethical point of view. At the most fundamental level, it is clear that the weight we should attach to the consequences for future generations is ultimately an ethical question. However, this does not necessarily imply that ethics should guide the parameter choices. Indeed, if one could compensate future generations in some other way, it may still be optimal to choose an 'efficient' market interest rate irrespective of the ethics argument. Nevertheless, if one considers such compensations unlikely, it still makes perfect sense to discuss the Ramsey rule from an ethical perspective, even if this results in a discount rate that differs from the market interest rate, whether viewed from the consumption or the production side.

BE in itself has not very much to contribute to ethics. However, insights from BE are sometimes also used in normative analysis. For example, as mentioned, much evidence suggests that people have self-control problems, and this is suggested as one of the reasons behind the fact that many smokers continue to smoke even though the majority would like to quit, and have even tried to quit. Gruber and Köszegi (2001) argue that this justifies a substantial tax on the 'internalities' of smoking. This is based on the idea that in a situation where people are not necessarily doing what is best for themselves, it is their experienced utility, or well-being, rather than their decision utility, as reflected by their choice, that matters from a normative perspective (see Kahneman *et al*., 1997; Kahneman and Thaler, 2006). Similarly, there is an emerging literature on 'soft paternalism', suggesting that it is often possible to help people make better decisions for themselves without compromising their liberty to choose (Thaler and Sunstein, 2003; Camerer *et al*., 2003). The most obvious example is to change the default alternatives, which has been shown sometimes to have dramatic effects on people's choices (Thaler and Bernartzi, 2004). We believe that this has

implications also for the climate-change problem (see Thaler and Sunstein, 2008). What ultimately matter are the welfare implications, and these cannot always be inferred from revealed behaviour.

The Stern (2007) review clearly uses ethics to justify the low δ, i.e. the pure time preference. However, as pointed out by Dasgupta (forthcoming), Beckerman and Hepburn (2007), and Dietz *et al*. (forthcoming), ethics is involved in choosing the σ-parameter, too. To illustrate, suppose we let $\delta = 0$, and assume, first, that there is no consumption growth in the next 100 years. Those living 100 years from now will then be just as wealthy as we are, no richer and no poorer. A cost of 1 billion dollars will presumably hurt them just as much as it hurts us, and the costs are therefore given equal weight irrespective of when they occur.

However, if we assume, like Stern (2007), that consumption grows at a rate of 1.3 per cent per year, then those living 100 years from now will be 3.6 times as rich as we are. Hence, a billion-dollar loss will hurt them less in welfare terms (provided that the representative utility function is concave). It is debated whether it is, in principle, possible to observe how much less they will be hurt in welfare terms; this relates to the classical debate about the extent by which it is possible to make interpersonal comparisons of well-being. The literature discussing these parameters assumes interpersonal comparisons, and in this perspective it follows that the larger the σ, the lower the weight to the future, provided that they are richer than we are. Stern (2007) assumes that $\sigma = 1$, so that the marginal utility of income is inversely proportional to income itself. This implies that the well-being of an additional billion dollars today corresponds to the well-being of 3.6 billion dollars 100 years from now.[6] This also implies that a 1 per cent consumption increase of the rich will *per se* be perceived to be equally as valuable as a 1 per cent consumption increase of the poor. Dasgupta (forthcoming) argues that this puts too little emphasis on the needs of the poor.[7]

We do, however, think that an ethical assessment also needs to take into account the distribution of income *within* each generation (cf. Azar and Sterner, 1996; Anthoff *et al*., forthcoming). In particular, climate change will most likely cause the most serious damage to the relatively poor in the future, too. The average income for the poorest third of the world's population is currently around $500 per year. Assuming a very optimistic consumption growth rate for the poor of 3 per cent annually, the descendants of these people will earn about $9,600 per year 100 years from now. However, this is still less than the current OECD consumption average of at least $15,000 per year.[8] This means that if one applies the ethical reasoning behind the Ramsey formula, while ignoring the pure rate of time preference for a moment, then the weight of the future costs (the future poor part of the world) relative to the present costs (in OECD countries) equals $(15{,}000/9{,}600)^{\sigma}$ (see Johansson-Stenman, 2005). With $\delta = 0.1$ and $\sigma = 1$, as suggested by Stern, this corresponds to a negative annual discount rate of –0.3 per cent per year. Moreover, with $\delta = 1.5$ and $\sigma = 2$, as suggested by Nordhaus (2007) as the baseline discount rate in his DICE-2007 model, the implied discount rate increases, but only slightly, to 0.6 per cent per year. The reason is that the higher δ is offset by the higher σ, which here implies a higher weight for the future. These simple calculations are intended

[6] Including the pure time preference of Stern, $\delta = 0.1$, one billion today corresponds to four billion 100 years from now.

[7] However, as pointed out by Dietz and Stern (2008), most cost–benefit analyses do not use welfare weights at all, corresponding to $\sigma = 0$.

[8] Based on the GDP *per capita* of $27,700 from OECD (2005), together with the conservative assumption that consumption constitutes 60 per cent of GDP.

to illustrate the danger of ignoring the distribution within generations when discussing the distribution among generations.[9]

(iii) Summary of the discount rate

To summarize our discussion thus far, we would argue that if interest rates are to be determined from the production side, the CAPM would indicate an interest rate that is hardly higher than the risk-free rate, as global warming presumably adds to future uncertainty. While it is not entirely clear how different explanations of the equity premium would change this conclusion, none of those discussed here pulls in the direction of an interest rate above the risk-free rate. Determining the risk-free rate is another matter, where at least treasury bills yield a remarkable low return. From the demand side, the parameters of the Ramsey equation are essential, and some estimates suggest that $\sigma > 1$, and is even closer to 2. On the other hand, self-control issues may lead to overstatements of σ, as people would have liked commitment devices to allow them to save more. Finally, it is not obvious that individual time preferences should be used in matters of distribution among individuals. A high σ then implies a higher discount rate, but also much more emphasis on damages that affect the poor. The latter effect may very well dominate the former, if it is taken into account that the damage of climate change will most likely affect the relatively poor in the future, too.

III. Social preferences and the behaviour of individuals and nations

The climate can be seen as a global public good, since we can all benefit from it and we cannot hinder others from benefiting, too. This is also the core of the problem, since what is rational for a single country in isolation is globally suboptimal. If each country has to pay for its own abatement costs of reducing the greenhouse-gas emissions, while all countries now and in the future will share the benefits, then there is clearly room for free-riding so that each country may continue to emit much more than is globally optimal. In order to prevent this, we need multilateral negotiations to obtain a cooperative solution.

By now there is a relatively large game-theoretic literature on negotiations related to transnational pollution (see, for example, Carraro and Siniscalco, 1998; Asheim *et al*., 2006). Some of this literature concerns repeated games, i.e. that negotiations do not occur only once but several times, and some take into account that the negotiating parties are asymmetric, since some countries are much bigger and more powerful than others. Moreover, parts of the literature concern the possibility for collusions, i.e. that some countries may cooperate against others, and other parts, so-called differential games, deal with both the strategic interaction and the complicated dynamic optimization simultaneously. However, a common denominator in almost all of this literature is the assumption that each negotiating country (or unit) will solely take into account its own material pay-off in the negotiations (Barrett, 2005), which mimics the conventional microeconomics assumption for individual behaviour.

[9] We do not suggest that it is necessarily advisable to lump both aspects of distribution into one single parameter. Sensitivity analysis in Stern (2007) also finds that the present value can be non-monotonic in σ.

(i) Conditional cooperation, reciprocity, and social norms

By contrast, in BE there is a large experimental literature at the individual level in which attempts are made to understand under what conditions people cooperate, even when it is not in their own material interest. Many experimental results can be interpreted in terms of *conditional cooperation*, suggesting that many people are willing to choose the cooperative alternative, but only if others do, too (Gächter, 2007). For example, Fischbacher *et al*. (2001) found that a large fraction of subjects increased their contributions in a one-shot public-good game if others did so too. Similarly, and perhaps more importantly given that laboratory environments are rather artificial (Levitt and List, forthcoming), there is much evidence from the field suggesting that people's willingness to contribute to good social causes increases with their perception of the contribution of others. For example, Frey and Meier (2004) analysed the behaviour of students in Zurich who had the opportunity to contribute to two social funds every semester, and found that they gave higher contributions after being informed that many other students were contributing. Shang and Croson (2006) and Alpizar *et al*. (2008) investigated how contributions to good causes (a public radio station and a natural park, respectively) are affected by information about a typical contribution by others; both studies found a positive relationship.

There is also much evidence from laboratory experiments consistent with reciprocity, in the sense that people reward kind and punish unkind actions *towards them* (cf. Falk and Fischbacher, 2006; Rabin, 1993). Note that this meaning of reciprocity does not presuppose that people necessarily reciprocate in order to gain in the long run. On the contrary, Fehr and Gächter (2000*a*) provide much evidence, both from experiments and real life, suggesting that people often reciprocate also in one-shot interactions. Falk (2007) and Alpizar *et al*. (2008) present the only field experiments of which we are aware that study reciprocity directly. Both studies found that people contribute more to charity after a small gift has been given to them. Cialdini (2001) provides a number of real-world examples, from fund raising to politics, where the principle of reciprocity plays an important role. There is also evidence that the perceived kindness of an action is generally not only evaluated in terms of the consequences of the action; perceived intentions matter, too (Dufwenberg and Kirchsteiger, 2004; Falk *et al*., 2008). Thus, kind actions are less likely to be reciprocated if the intentions behind them are perceived as bad.

Reciprocity can be seen as an example of a rather fundamental *social norm*. Such norms can also be more specific, e.g. the norm to recycle. Environmental labelling, or eco-labelling, is a policy instrument that makes use of people's willingness voluntarily, or perhaps partly influenced by peer pressure, to behave in an environmentally friendly fashion; see Stephan (2002) for an overview. In a situation where people are motivated by social norms, it is important to consider how conventional policy instruments, such as command-and-control and environmental taxes, influence the mechanism of the social norms. Sometimes external policy instruments strengthen the norms, typically denoted a *crowding-in effect*, and sometimes they weaken the norm, i.e. a *crowding-out effect*; see Frey and Oberholzer-Gee (1997), Gneezy and Rustichini (2000), and Brekke *et al*. (2002).

(ii) Individual cooperation *vs* group cooperation

While it is certainly not straightforward to generalize the experimental findings from individuals to a multi-country negotiation setting, we do believe that some of the insights are

transferable, if not quantitatively at least qualitatively. First, there is an emerging literature on group decision-making. From this literature, however, it is ambiguous as to whether people become more 'cooperative' in a group decision situation compared to when acting as individual decision-makers. An often-cited reference is Cason and Mui (1997), who found teams to be more altruistic and other-regarding than individuals. However, Luhan *et al*. (forthcoming) argue that the Cason and Mui study constitutes an exception, and that most studies, including their own, find that groups of people are typically less altruistic or cooperative than individuals. On the other hand, Dannenberg *et al*. (2007) found in an experimental study that climate-policy negotiators have stronger preferences for equity compared to students who are typically used as subjects.

Second, there is an economic literature on voting behaviour. The conventional rational-actor voting model has been unsuccessful both in explaining *why* people vote, since the expected benefit from voting is so small compared to the time cost and effort of voting, and in explaining *how* people vote, since there is much empirical evidence that we *do not* solely vote in our own material self-interest (e.g. Mueller, 2003). So, why do we vote? According to Brennan and Hamlin (1998, 2000), one reason is that there is a utility gain from expressing an opinion through voting; see Sobel and Wagner (2004) and Tyran (2004) for empirical and experimental evidence. If the expressive motive is important it also seems more likely that people are more concerned with society as a whole when voting, rather than with what is good solely for themselves. Indeed, as found by, for example, Brekke *et al*. (2002), most people seem to prefer a self-image that reflects social responsibility rather than pure self-concern, and Tyran and Sausgruber (2006) found that self-centred inequality aversion, as suggested by Fehr and Schmidt (1999), can explain much of the voting behaviour in a voting experiment. Taken together, the evidence suggests that the case for actions beyond the narrow self-interest is most likely often present also at the country level, although it is unclear whether or not countries are likely to act more cooperatively than individuals.

(iii) The darker side of human behaviour

However, it should be emphasized that BE does not only bring good news about human behaviour. For example, there is much systematic evidence in favour of *self-serving bias*. Babcock and Loewenstein (1997) observed that in wage negotiations, both parties (employers and employees) seem to accept that the wage level for comparable groups is a relevant factor in determining local wages. They then asked employers and employees to list comparable work places. Not surprisingly, the average wages at the work places on the employers' list were lower than those on the employees' list. This is one example of the phenomenon that when facts or principles are ambiguous, we tend to pick the ones that favour our own self-interest. Babcock and Loewenstein also found that the larger the differences in wages between the lists, the higher the probability of a conflict in the wage negotiations. Thus, although people typically care quite a bit about fairness, our perception of what is fair tends to be influenced by what is in our own interest, and this often affects our actions, including how we tend to vote. According to Elster (1999, p. 333): '*Most people do not like to think of themselves as motivated only by self-interest*. They will, therefore, gravitate spontaneously towards a world-view that suggests a coincidence between their special interest and the public interest' (italics in original). Although a preference for equity may improve the possibilities for cooperation in climate negotiations (see Lange and Vogt, 2003), this is much less clear when the equity principles used are influenced by self-serving bias (Lange *et al*., 2007).

Similarly, much evidence suggests that people tend to deceive themselves into believing that they are in various ways 'better' than they really are (Baumeister, 1998), including in ethical issues, in order to improve or preserve their self-image. Related to this, there is evidence that we often try to avoid situations where we know that we will feel the pressure to act in accordance with the norms, e.g. due to shame, if these norms are in conflict with our own material self-interest. For example, Dana *et al*. (2006) offered their subjects the choice between playing a $10 dictator game and an exit option in which the subject receives $9 instead of playing the game; if the dictator chose the exit option the receiver was not told about the existence of a game (and a potential sender). Many subjects chose the exit option. Broberg *et al*. (2007) provide similar results. This can obviously not be explained by standard selfish preferences, in which case all subjects should have preferred the $10 dictator game and kept everything for themselves. Nor can it be explained by a combination of preferences for own pay-offs and pay-offs for the other player (or distribution of pay-offs). Rather, it seems that people dislike it when others think badly of them, even in cases like this when the game was anonymous. Somewhat similarly, Dana *et al*. (2007) provide evidence that when there is a certain amount of uncertainty induced between people's actions and the resulting outcomes, subjects tend to use this 'moral wiggle room' to behave more self-interestedly. This can also imply that people, including policy-makers and politicians, in the richer parts of the world simply try to avoid some of the ethical discussions related to climate change. For example, it is hard to come up with a defendable ethical theory suggesting that just because the poorer countries have emitted less greenhouse gases in the past they are obliged to do so also in the future, unless they are adequately compensated for this.[10] Yet, this is what many global emission reduction plans suggest.

There is also much evidence in favour of what psychologists term 'cognitive dissonance' (Festinger, 1957), which suggests that inconsistency between beliefs and behaviours causes an uncomfortable psychological tension, sometimes implying that people change their beliefs to fit their behaviour, instead of changing their behaviour to fit their beliefs (as is conventionally assumed). With respect to climate, this may imply that people who cause large greenhouse-gas emissions, e.g. many people in the USA, tend to believe that the climate-change problems are overstated; see, for example, Stoll-Kleeman *et al*. (2001). Thus, it may not only be that those who believe that climate change is a serious threat for this reason adapt their behaviour accordingly and emit less; the causality is also likely to go in the other direction.

In addition, there is experimental evidence that people's behaviour in repeated games tends to become less cooperative over time and converges towards the conventional Nash equilibrium, unless there is a possibility of punishing free-riders (Fehr and Gächter, 2000*a*,*b*) so that cooperation can be maintained. Kroll *et al*. (2007) showed experimentally that voting alone does not increase cooperation, but that if voters can punish violators, then contributions increase significantly. On the other hand, Dreber *et al*. (2008) found that costly active (destructive) punishment (as in Fehr and Gächter, 2000*a*,*b*) is far less effective than punishment in terms of lack of continued cooperation (such as tit-for-tat). Ostrom (1990) provides extensive real-world evidence that sanction possibilities are essential for successful common-property

[10] One straightforward way of incorporating an adequate compensation mechanism would be to introduce a global system of tradable permits, where the initial allocation is proportional to the population size in each country. Or, with a very similar distributional implication, impose a global tax on the emission, where the revenues are distributed back in proportion to population size. Furthermore, one may argue that poorer countries should have the right to emit more than the richer countries in the future, in order to compensate for their lower emissions in the past. However, that this appears ethically reasonable (e.g. Kverndokk, 1995) does not, of course, imply that it is politically feasible.

resource management, and Gürerk *et al*. (2006) present experimental evidence that people tend to prefer an institution where they have the ability to punish free-riders, compared to an institution without this possibility.

(iv) Implications for climate negotiation

Taken together, what can we learn from the BE literature on cooperation for climate negotiations? First, people, and also countries, are able to make decisions that are not in their own material interest if they have other sufficiently strong reasons for doing so, such as obtaining a situation that is overall socially desirable and if this can be obtained in a way that is perceived as reasonably fair. Second, when individual parties analyse what a fair outcome should look like, they are typically influenced by self-serving bias, and this makes it more difficult to reach agreements. Third, negotiating parties are likely to avoid looking at information that would force them to reflect over ethical issues. A potential policy implication is, therefore, to emphasize such information to the point where it is impossible for the negotiators to ignore it (Nyborg, 2007). Fourth, the possibility of using sanctions and punishments seems essential for the longer-term effectiveness of a climate agreement. The Kyoto protocol and the forecasts for the next agreement currently lack this possibility. This serious drawback was emphasized by Barrett (2003, 2007); see also Stiglitz (2006) for a suggestion of linking the climate and trade negotiations, leading to countries that fail to act responsibly in the climate area being punished by tolls. The potential success of the latter strategy is also consistent with the experimental evidence of Dreber *et al*. (2008), but there are, of course, large political obstacles that need to be solved before an effective system of sanctions can be agreed upon.

IV. Conclusion

In this paper we have incorporated some important aspects of BE into the economics of climate change, in particular with respect to the discount rate and climate negotiations. We have argued that the choice of discount rate cannot be disentangled from the explanations of the equity premium puzzle, and that a discount rate closer to the risk-free rate than to the average return on investments is advisable, both when we use the classical CAPM and when a BE explanation of the equity premium is used. We also discussed the ethics of discounting, noting, for example, that climate changes will likely harm the future poor. If the future poor are poorer than the rich are today, then their marginal utility of income would be correspondingly larger, implying a higher weight according to the basic logic behind the Ramsey discounting rule. Overall, there are several reasons why it appears advisable to choose a substantially lower social discount rate than the average return on investments.

We have also discussed climate negotiations where BE has a positive message, as studies have found that humans are less self-serving than the economic man. The evidence suggests, however, that cooperation is conditional, underlining the importance of sanctioning mechanisms in negotiated agreements. Thus, although taking social preferences into account seems to increase the possibilities of obtaining international agreements, compared to the standard model, there are also effects going in the opposite direction, such as self-serving biases.

Naturally, there are many important aspects that lack of space has prevented us from discussing. For example, global climate change implies risks of potentially very substantial damages. Indeed, according to the palaeontologist Peter Ward (2006), in the last 500m years

most life forms on earth simply died out at five different points in time, four of which were probably due to global warming from endogenous (although, of course, not anthropogenic) changes on earth.[11] There is clearly much beyond the standard theory, and beyond what we have touched upon here, to be said about how people react to catastrophic and other risks.

The issue of political feasibility, i.e. what makes people support some measures but not others, is another important area where insights from BE and psychology are important. Moreover, as noted by many great economists in the past (including Adam Smith, John Stuart Mill, Arthur Pigou, and John Maynard Keynes), people do not only derive utility from their absolute income, but also from their income relative to others; see, for example, Aronsson and Johanson-Stenman (2008) and Brekke and Howarth (2002). This suggests that the welfare effects associated with abatement costs may be substantially lower compared to the base case when not taking relative income effects into account.

Finally, researchers are also, of course, affected by the same psychological mechanisms. For example, there is much evidence suggesting a *confirmatory bias*, i.e. a tendency to search for or interpret information in a way that confirms one's preconceptions and to avoid information and interpretations that contradict prior beliefs; see, for example, Rabin and Schrag (1999). While we as scientists tend to think of research as a process where our conclusions follow from our assumptions and perceptions of the world, the existence of confirmatory bias suggests that the link sometimes may go in the opposite direction. This perspective suggests that economists who, for whatever reason, consider it important to take drastic action against climate change today (coincidentally, the authors of this paper belong to this group), would tend to believe that low parameter values in the Ramsey discounting formula are more appropriate. Similarly, those who believe the climate issue to be overstated, and that there are many other issues that we should prioritize instead, would tend to believe that high parameter values are more appropriate. Of course, we try our best to present balanced arguments, and knowing the difficulty in this we are particularly focused on finding important arguments against our own main conclusion (as other participants in scientific discussions do). Still, we leave it to the readers to judge whether or not we have been affected by confirmatory bias in our arguments for relatively low discount rates. We strongly encourage more research that incorporates BE into the economics of climate change.

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[11] The fifth, and the one that killed off the dinosaurs, was according to the same source largely due to a meteor impact. We are grateful to David Hendry for directing us to this research.

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