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BEHAVIORAL ECONOMICS, NEUROECONOMICS, AND CLIMATE CHANGE POLICY: BASELINE REVIEW FOR THE GARRISON INSTITUTE INITIATIVE ON CLIMATE CHANGE LEADERSHIP

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BEHAVIORAL ECONOMICS, NEUROECONOMICS, AND CLIMATE CHANGE POLICY: BASELINE REVIEW FOR THE GARRISON INSTITUTE INITIATIVE ON CLIMATE CHANGE LEADERSHIP[1]

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"Reality is infinitely various when compared to the deductions of abstract thought, even those that are most cunning, and it will not tolerate rigid, hard and fast distinctions. Reality strives for diversification." - Fyodor Dostoyevsky, *The House of the Dead*

ABSTRACT

In spite of the increasing scientific certainty that the earth's climate is warming and that human activity is partially responsible, public willingness to take steps to reduce greenhouse gas emissions seems to be decreasing. How can the scientific consensus as to the urgency of the climate change problem be conveyed to the general public in such a way as to support greenhouse gas abatement policies and to actually change behavior? This essay explores the standard economic approach to environmental pollution and discusses findings from behavioral economics and neuroscience that could lead to a more fruitful understanding of the relationship between economic policy and human psychology. This essay is a background paper prepared for the Garrison Institute's "Climate, Mind and Behavior" initiative.

I. The Gulf between Science and Public Perception in the Climate Change Debate

The climate change debate has taken on a new urgency with the latest scientific information about current CO_2 emissions, projections of future CO_2 levels, and past climate regimes. Between 1990 and 1999, CO_2 emissions grew at a rate of 1.1% per year. Since 2000 the annual growth rate has been above 3% (Raupach et al. 2007). Recent emission rate projections are substantially higher than those of the Intergovernmental Panel on Climate Change (IPCC) or the Stern Review, primary because of coal burning in China (Auffhammer and Carson 2008; Botzen, Gowdy, van den Bergh 2008). In view of the magnitude of emission increases it seems unlikely

that a "safe" level of atmospheric CO_2 can be maintained. Based on several independent lines of reasoning and evidence, including controlled greenhouse experiments, past climate records, and computer modeling, we know that past fossil fuel emissions alone will eventually cause the earth to heat by several degrees Celsius. Over the past 800,000 years atmospheric concentrations of CO_2 have varied between 180ppm and 280ppm (Dichter et al. 2008). CO_2 levels during this period are positively and tightly correlated with temperatures and sea levels. These 50ppm fluctuations around the average of 230ppm were enough to push the earth between warm periods comparable to today's climate to extremely cold ice age conditions. In 2009 atmospheric CO_2 levels measured at Mauna Loa, Hawaii reached 390ppm, an increase over preindustrial levels of more than 100ppm. A recent article in *Science* (Tripati, Roberts and Eagle 2009) reports that during the Middle Miocene, some 10-14 million years ago, CO_2 levels were about the same as today's but temperatures were 3C to 6C warmer and sea levels were 25 to 40 meters higher. If past climate regimes are an indication of what we can expect in the future, larege, abrupt, and unpredictable changes can be expected in the coming centuries.

The chances of limiting CO_2 emissions to a level consistent with today's stable climate regime are bleak. CO_2 levels could reach 2000 ppm within a few centuries if the readily available coal, petroleum and natural gas are burned (Kump 2002). Kasting (1998) believes that the most likely scenario is that atmospheric CO_2 will peak at about 1200 ppm sometime in the next century. A climate-carbon model developed by Bala et al. (2005) has the business-as-usual CO_2 peak occurring around the year 2300 at 1400 ppm. Recent emissions scenarios by the IPCC include a worst case, carbon intensive scenario projecting a level of 1370 ppm by 2100 (Kintisch 2008). Obviously, if CO_2 levels reach these extremes, abrupt and catastrophic climate events are all the more likely. A recent re-examination of CO_2 levels during extreme "hothouse earth" climate regimes indicates that levels were around 1000ppm, not 3,000-4,000ppm as previously thought (Newton 2010). The scientific consensus is that delaying emission reductions for even a few more years may be disastrous (Anderson and Bows 2008; Archer 2009; Jaeger, Schnellnhuber and Brovkin 2008).

But how can this information be conveyed to the general public in such a way as to support greenhouse gas abatement policies and to actually change behavior? There is a gulf between the scientific consensus as to the seriousness of the risks of climate change and public perception of the problem. More than half of Americans, about 54% (Leiserowitz 2007), favor a

wait-and-see approach to emissions reduction policies. Studies have shown that even well-educated people have difficulty with problems involving even moderately long chains of causality (Sterman 2008). Complicating public perception of the problem is the fact that climate change science is still plagued with uncertainty about the timing of future warming and the role of various feedback mechanisms accelerating or delaying the impacts of current fossil fuel use. It has been suggested that public acceptance of the aggressive policies needed to mitigate the most serious damages from further climate change could be enhanced by a better understanding of the mental models people use to evaluate long term risks (Leiserowitz 2006). Most Americans are concerned about climate change yet they are reluctant to support the public policies required to mitigate it or to change personal behavior (Jamieson 2006; Oppenheimer and Todorov 2006). One reason seems to be that they view the problem as affecting those in the distant future and those in distant countries. Another reason is more basic. Humans, like other mammals, evolved to respond effectively to immediate threats. It is difficult for most people to respond forcefully to the threat of climate change, with all its uncertainties about magnitude and timing, when we face so many more immediate concerns.

Another complicating factor shaping attitudes about climate change is the "groupishness" of human behavior (van den Bergh and Gowdy 2009). On major issues, including climate change, opinions are often adopted to conform to those of a person's reference group rather than to objective scientific information. The good news is that humans are not bound by hard and fast behavioral rules. Humans are to a large extent unique among the animal kingdom in their ability to empathize with others and plan for the distant future. As indicated by an array of popular books (*Nudge*, *Predictably Irrational*, *Animal Spirits*), economists are relying more and more on behavioral science for insights into human behavior. Behavioral economics and neuroscience is beginning to uncover patterns that may help to formulate effective policies and design effective institutions to meet the growing threat of disruptive climate change.

II. What is Behavioral Economics, What is Neuroeconomics?

The field of economics has prospered over the last century by focusing its attention on a few key insights—the importance of individual incentives in motivating behavior, that humans strive to do the best they can with the limited means at their disposal, and the ability of economic actors to *self-organize* to efficiently solve resource allocation problems. These insights are

deeply rooted in Western culture (Sahlins 1996) and are central themes in the Classical Economics of Adam Smith, David Ricardo and John Stuart Mill. In many ways behavioral economics is a return to the psychological foundations of economics that was all but abandoned when economic theory was recast as a purely mathematical problem of constrained optimization. The mathematical requirements of the constrained optimization approach are embodied in neoclassical assumptions about human behavior embodied in what is variously called "the rational actor model," "*Homo economicus,* or simply "economic man."

Behavioral economics began with the discovery by economists of so-called "anomalies" in human behavior, that is, deviations from the assumptions embodied in the neoclassical model. One of the first anomalies reported in the standard economics literature is the Allais (1953) paradox. Given the choice between a 100% chance of receiving $1 million dollars or a 50/50 chance of receiving either $2.1 million or zero, which would you pick? Almost everyone would pick the sure $1 million even though the expected payoff is higher for the second choice (.5 times $2.1million or $1,050,000). This directly contradicted the "independence axiom" of standard expected utility theory. Deviations from standard choice theory slowly accumulated in the economics literature as a growing number of economists recognized the importance of modern psychology in understanding economic behavior. During the 1950s and 1960s pioneers like Daniel Ellsberg, Harvey Leibenstein, Tibor Scitovsky, Herbert Simon, and Robert Strotz pushed the standard economic model toward more realism. In the 1960s and 1970s the field of psychology began to move closer to economics as the metaphor for the human brain changed from a stimulus-response mechanism to an information processing device (Camerer and Loewenstein 2004, p. 6). The convergence of these trends in economics and psychology had two important consequences that established the field of behavioral economics. First, criticism of rational economic man became focused on testable scientific hypotheses of consumer choice theory. It was no longer enough for standard economists to just say, "We don't believe your criticisms, we think humans are self-regarding utility maximizers." Once controlled experiments falsified basic assumptions of the rational actor model it was incumbent upon the defenders of the model to refute or accept the experimental results. The second consequence was the establishment of regularities in human behavior (loss aversion, reference dependency, the endowment effect, altruistic punishment). The final step, currently incomplete but well

underway, is to use the findings of behavioral economics to construct a more complete and science-based theory of human decision-making.

Neuroeconomics focuses on how the human brain processes information by measuring neural activity using sensory devices, eye-tracking and other physical indicators of brain activity. It is closely related to behavioral economics and also grew out of a reaction against neoclassical choice theory. Like behavioral economics, the field was inspired by the early work of Allais and Ellsberg, and also by Herbert Simon's theories of bounded rationality. In the 1970s Kahneman and Tversky constructed a number of psychological experiments involving choice, judgment, and decision making that not only further undermined rational choice theory but also laid the groundwork for neuroscientists to examine specific brain functions. Glimscher, Camerer, Fehr and Poldrack (2009, p. 4) write:

> "…[T]he neoclassical school had a clear theory and sharp predictions, but the behavioral economists continued to falsify elements of that theory with compelling empirical examples. Neuroeconomics emerged from within behavioral and experimental economics because behavioral economists often proposed theories that could be thought of as algorithms regarding how information was processed, and the choices that resulted from that information processing."

Today, modern non-invasive tools of neuroscience, like fMRI scanning, have made it possible to confirm that the behavioral regularities uncovered by behavioral economics have a physiological (and by implication, evolutionary) basis.

An interesting and somewhat ironic tension exists within neuroeconomics. Many economists see neuroeconomics as an alternative to the rigidities of the standard economic model while neuroscientists see that model as providing a needed theoretical framework to organize a mass of loosely related data. This tension is described by Cohen and Blum (Neuron 36(2) introduction to special issue on "Reward and Decision"):

> Within neuroscience, for example, we are awash with data that in many cases lack a coherent theoretical understanding…Conversely, in economics, it has become abundantly evident that the pristine assumptions of the "standard economic model"—that individuals operate as optimal decision makers in maximizing utility—are in direct violation of even the most basic facts about human nature.

Prominent neuroscientists (Glimscher for example) who were trained as psychologists envy the mathematical and logical precision of neoclassical theory and look to that model as a way of

organizing a rather disjointed field. On the other hand, prominent economists (Camerer, Loewenstein and Prelec, for example) see the "anomalies" uncovered by behavioral economics as a refutation of standard (Walrasian) theory. Neuroscience provides physiological evidence that neurobiological features of the human brain insure that most people do not act "as if" they are rational utility maximizers.

The one framework that can link behavioral economics and neuroeconomics is modern evolutionary theory. Human behavior is a complex outcome of the interactions between "nature" and "nurture". There is no hard and fast separation between the two. The belief that they are separate has been referred to as Descartes error—the separation of mind and body, reason and emotion (Demasio 1994). Behavior and the neurological structure of the brain have co-evolved over eons to solve some basic survival problems. In the case of humans, cultural behavior is a complex and complicating factor but it too can be analyzed using the basic Darwinian framework of variation, selection and retention of evolved traits (Hodgson 2004). The evolutionary perspective on behavioral economics and neuroeconomics is discussed in detail in Section XI below.

III. Back to Adam Smith: Returning Psychology and Common Sense Economics

Gintis (2007) suggests that the current revolution in behavioral economics and neuroscience is part of a larger on-going project—namely the unification of the social sciences along the lines of the unification of the natural sciences in the twentieth century. Over the last one hundred years or so the basic understandings of such diverse fields as biology, physics and chemistry were made to be *compatible* even though their subject matter is very different. For example, although they describe very different processes, the theory of natural selection does not contradict the laws of thermodynamics. By contrast, theories of individual human behavior held by economists, sociologists, anthropologists, and decision scientists are contradictory and incompatible. Gintis (2007, 2) writes:

> The behavioral sciences all include models of individual human behavior. These models should be compatible. Indeed, there should be a common underlying model, enriched in different ways to meet the particular needs of each discipline. We cannot easily attain this goal at present, however, as the various behavioral disciplines currently have incompatible models. Yet, recent theoretical and empirical developments have created the conditions for rendering coherent the areas of overlap of the various behavioral disciplines. The analytical tools deployed in this task incorporate core principles from several behavioral disciplines.

This is not to deny that each social science discipline will have its own realm of inquiry. Anthropologists will still study how entire cultures function and how humans physically evolved, sociologists will still study the institutions of modern societies, and psychologists will still study human mental functions and behaviors. Different disciplines will explore different aspects of human behavior and human cultures. But the basic assumptions of one discipline should be compatible with the assumptions of the other social sciences regarding "human nature." Making the economic model of behavior compatible with established facts from other behavioral sciences will not be an easy task. As Pensdorfer (2006, 712) points out, behavioral economics is largely organized around the failures of standard economics rather than being a stand-alone alternative. But an alternative is clearly needed. Results from behavioral economics, game theory, and neuroscience indicate that simply modifying the basic *Homo economicus* assumptions will not yield a satisfactory model of human behavior. Progress is being made by focusing on observing how and why people make choices, identifying consistent patterns in these observed choices, and determining how these choices might be predicted (Rieskamp, Busemeyer, and Mellers, 2006).

Behavioral economics and neuroeconomics represent a major step in the unification of the social sciences by bringing psychology back into economic theory. In many ways this is a return to the Classical roots of economics. Adam Smith's first major work was *The Theory of Moral Sentiments* and in many ways was a much more "modern" approach to economics than his most famous book *The Wealth of Nations*. Smith described human behavior in all its richness including sympathy and compassion for others:

> When we are always so much more deeply affected by whatever concerns ourselves than by whatever concerns other men; what is it which prompts the generous upon all occasions, and the mean upon many, to sacrifice their own interest to the greater interest of others? It is not the soft power of humanity, it is not that feeble spark of benevolence which Nature has lighted up in the human heart, that is thus capable of counteracting the strongest impulses of self-love. It is a stronger power, a more forcable motive, which exerts itself upon such occasions. It is reason, principle, conscience, the inhabitant of the breast, the man within, the great judge and arbiter of our conduct..." (Adam Smith, *The Theory of Moral Sentiments*, quoted in Heilbroner 1996, pps. 68-69)

Psychology and social context was important to economists during the hundred years following the publication of the *Wealth of Nations* in 1776. David Ricardo, Thomas Malthus, John Stuart Mill, and Karl Marx drew heavily on the incipient sciences of human behavior.

Adam Smith gave the world the metaphor of the "invisible hand" to describe the workings of the economic system. The economy is a marvelous self-organizing system that somehow coordinates production possibilities and consumer desires of billions of people every day. But Smith understood that economic activity takes place within a system of morality and social constraints on greed and avarice. Smith had no illusions about the benevolence of the merchant class nor was he blind to the darker aspects of capitalism:

> Civil government, so far as it is instituted for the security of property, is in reality instituted for the defense of the rich against the poor, or of those who have some property against those who have none at all. (Adam Smith, *Wealth of Nations*, quoted in Heilbroner 1996, p. 101)

> The man whose whole life is spent in performing a few simple operations, of which the effects too are, perhaps, always the same, or very nearly the same, has no occasion to exert his understanding, or to exercise his invention in finding out expedients for removing difficulties which never occur. He naturally loses, therefore the habit of such exertion, and generally becomes as stupid and ignorant as it is possible for a human creature to become. (Adam Smith, *Wealth of Nations*, quoted in Heilbroner 1996, p. 102)

> The interest of the dealers, however, in any particular branch of trade or manufactures, is always in some respects different from, and even opposite to, that of the publick. To widen the market and narrow the competition, is always the interest of the dealers…The proposal of any new law or regulation of commerce which come from this order, ought always to be listened to with great precaution, and ought never to be adopted till after having been long and carefully examined, not only with the most scrupulous, but with the most suspicious attention. It comes from an order of men, whose interest is never exactly the same as with that of the publick, who have generally an interest to deceive and even to oppress the publick, and who accordingly have, upon many occasions, both deceived and suppressed it. (Adam Smith, *Wealth of Nations*, quoted in Heilbroner 1996, pp. 94-95)

Smith would have been quite comfortable with the insights from behavioral economics regarding the importance of fairness, social context and other-regarding behavior. He argued strongly that the interests of the business class frequently conflicted with those of civil society. One of his three reasons for the existence of government (along with national defense and establishing a system of justice) was to provide public works and public institutions that it "cannot be expected that any individual or small number of individuals should erect or maintain" (quoted in Heilbroner 1996, p. 102). Smith, like the other Classical economists, saw clearly the dangers of unbridled markets and the need for government provision of public goods.

The scope of economic theory and policy was narrowed considerably after the "marginalist revolution" in the 1870s. With the importation from thermodynamics of mathematical models of equilibrium in a field of forces the richness of Smith's invisible hand metaphor was reduced to a purely mechanical process of efficient resource allocation (Gowdy 2009a, Mirowski 1989, chapter 5). In the stripped-down model of rational allocation, economists had no use for insights from psychology. Vilfredo Pareto wrote in 1897:

> It is an empirical fact that the natural sciences have progressed only when they have taken secondary principles as their point of departure, instead of trying to discover the essence of things…Pure political economy has therefore a great interest in relying as little as possible on the domain of psychology (Quoted in Glimsher et al. 2009, from Busino 1964).

During the twentieth century, especially in the decades following WWII, the dominant view among economists was that preference formation need not be analyzed since it could be directly observed in market choices (revealed preference) and, assuming consistency in choice and self-regarding behavior, it could be described by simple mathematical axioms. To understand the importance of the behavioral revolution in economics it is necessary to have some grasp of the essential features of neoclassical welfare economics.

IV. Neoclassical Welfare Economics

One reason for the enthusiastic reception of the system developed by Pareto, Leon Walras and a few others was that it provided a rigorous and much more sweeping proof of the social goodness of Adam Smith's invisible hand. An unfettered market economy will lead naturally to the greatest possible social welfare, namely to a position where no further trading of goods or productive inputs can improve the situation of one person without harming another (called *Pareto optimality*). This is the central tenet of neoclassical economics:

> *The First Fundamental Theorem of Welfare Economics*:
>
> Assume all individuals are selfish price takers. Then a competitive equilibrium is Pareto optimal (Feldman 1987, IV, 890).

The *First Fundamental Theorem* is a powerful result of the axioms of consumer choice and calculus of constrained maximization. The free trade of goods and services in a perfectly operating market economy, with a given income distribution, will automatically lead to a situation such that there is no feasible alternative that would make society better off.

Homo economicus is central to neoclassical welfare economics. The point of Walrasian theory is to demonstrate that competitive markets are Pareto optimal. To prove this theorem it is necessary to assume that economic agents are self-regarding (not just "selfish"). Other-regarding preferences include envy, status-seeking, and retaliation as well as altruism. Without the self-regarding assumption it cannot be proved that free trading of goods among individuals will lead to the point where the marginal rates of substitution for goods are the same for all individuals. And this result is needed to go on to prove the First Fundamental Theorem. This may seem esoteric but the First Fundamental Theorem is one of the great achievements of economic theory, that is, to demonstrate the logical and mathematical possibility of Adam Smith's invisible hand. The Walrasian framework reflects the worldview of many if not most economists—competition in free markets leads to the greatest social good. The basic starting point of economic analysis, going back to Adam Smith at least, is something like "people do the best they can with the limited means at their disposal." But economics took a wrong turn when this common sense observation became severely restricted to something like "self regarding individuals employ perfect logic to maximize a smooth, single-valued, twice differentiable consumption function ". This is not to deny that markets are a powerful tool for allocating scarce resources. But evaluating whether or not particular markets achieve the best possible allocation should be based on empirical evidence, not on mathematical derivations.

The problem is not just that humans are characterized as "selfish" but that they are "self-regarding." In the rational actor model, one person's evaluation of a payoff does not depend on what others have or think. This is clearly false and leads to poor predictions of actual human behavior as illustrated by the results of the Ultimatum Game (see below) and other behavioral experiments as well as direct evidence from neuroeconomics about physical brain activity.

There is also a Second Fundamental Theorem of Welfare Economics that recognizes that markets may be imperfect.

The Second Fundamental Theorem of Welfare Economics:

> Assume that all individuals and producers are selfish price takers. Then almost any Pareto optimal equilibrium can be achieved via the competitive mechanism, provided appropriate lump-sum taxes and transfers are imposed on individuals and firms. (Feldman 1987, vol. IV, 891)

The second theorem is actually a wide open justification for market intervention. It can be used not only to correct market failures but also to impose a more fair distribution of income if society so decides. But the second theorem is also based on self-regarding behavior. The reason that market outcomes are imperfect is not that people are "irrational" but rather that they are responding rationally to "wrong" price signals. These wrong prices can in theory be corrected by enlightened intervention in markets so that Homo economicus can choose efficiently to achieve Pareto efficiency. But the recognition that markets may be imperfect does not negate the fact that economic theory is based on the assumption of autonomous individuals automatically self-organizing to assure the common good.

The whole issue of rationally in economics is a minefield of politics, distribution, social justice, etc. If market outcomes do not reflect the results of rational choice then there is nothing sacrosanct about any particular outcome. Markets may be "pretty good" allocators of goods and resources (given a "fair" initial income distribution and appropriate market failure corrections) but this is very different than saying they produce the "best" outcome (when corrected for externalities and public goods). This is what extreme free-market advocates fear. "Irrational" behavior calls into question the belief that free choice in competitive markets is the key to achieving the greatest social good and this opens the door of public regulation far beyond "internalizing externalities." Without the axioms of rational consumer choice, including the assumption that the preferences of any person are independent of those of all other persons, it cannot be proved that Adam Smith's invisible hand will lead to the common good. It is no wonder that so many economists are reluctant to accept the claims of behavioral economics and neuroeconomics regarding human behavior.

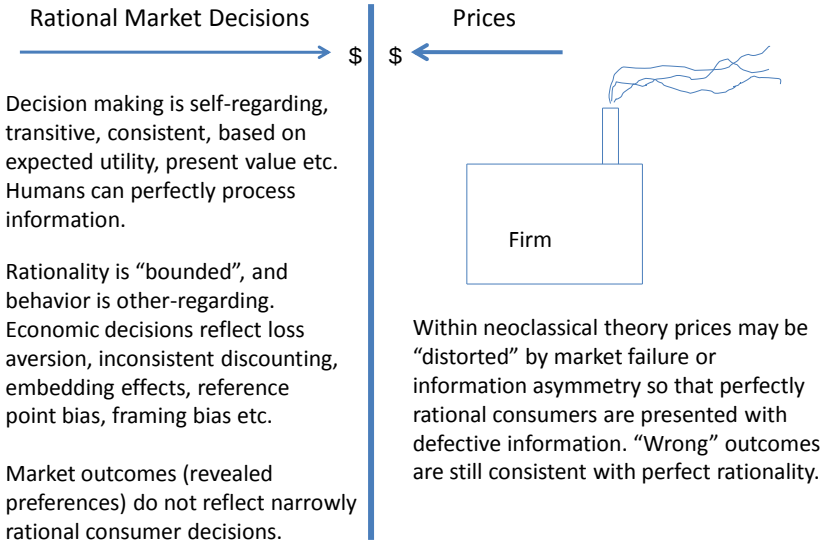

Figure 1. Market outcomes may be imperfect due to wrong prices or wrong decisions.

In standard theory consumers make rational market choices based on the relative prices of goods and services. Economists recognize that sometimes markets are imperfect and that market prices might not reflect the true cost of production (the social costs of a firm's pollution for example). This is covered by the Second Fundamental Theorem which recognizes that governments have a legitimate role in making sure that markets are competitive and that the true costs of producing a good is reflected in its price. But there is no Fundamental Theorem to cover "irrational" decision making on the part of individual consumers (see Figure 1). Again, if market choices ("revealed preferences") are not rational then there is nothing sacrosanct about market outcomes. Choices made even in perfectly competitive markets do not automatically reveal what's best for society. This is the underlying reason why so many economists get so upset with criticisms of the rational actor model. Rational consumers are the lynchpin of the First Fundamental Theorem of welfare economics.

V. The Mismatch between Neoclassical Theory and Climate Change Reality

The most widely used economic models of climate change, including those of Cline (1992), Nordhaus (1994), Stern (2007) and others examine climate in a *general equilibrium* framework. In this framework climate change protection is treated as just another possible

investment to improve society's well-being as measured by the consumption of market goods. For example, in Nordhaus' models the general equation for intergenerational economic welfare is:

$$W(t) \equiv \int_0^{\infty} U[C(\tau)] e^{-r(\tau - t)} d\tau \qquad (1)$$

where "total welfare" W(t) is to be maximized over all feasible consumption paths C(τ). Utility is characterized by a broadly defined utility function , U[C(τ)], which includes both direct and indirect consumption at time τ, τ- t is the specific time period considered, and r is the social discount rate. The condition for intergenerational sustainability is:

$$dW(t)/dt \geq 0 \qquad (2)$$

This is the "weak" or "economic" definition of sustainability: a sustainable economy requires non-declining welfare (the stream of consumption goods) over time (Stavins, Wagner and Wager, 2002).

The mathematical requirements and consequences of this model have surprising implications for climate change policy as shown in Figure 2. Any spending on climate change mitigation necessarily means reducing (the present discounted value of) economic output because capital is diverted from producing consumer goods. The only reason to invest in climate change mitigation by choosing path **B** over path **A** is if the potential economic damage from climate change is greater than the cost of mitigation. It is a wholly static view of economic activity that ignores the potential economic benefits of spurring new energy efficient industries and technologies. Furthermore, in most models the only industry directly affected by climate change is agriculture so the immediate (marginal) effects of climate change on economic output are small (Beckerman, Nordhaus, Shelling).

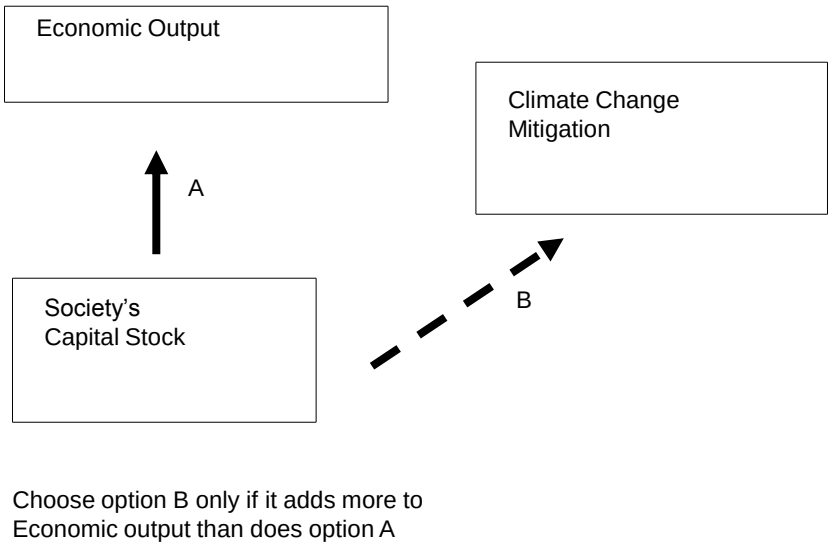

Figure 2. When to invest in climate change

The Choice of a Discount Rate

The choice of a discount rate is critical in economic models of climate change and for environmental economics in general. Neoclassical economists approach resource allocation problems using a financial investment model—a capital investment approach. Resources should be allocated to those investments yielding the highest rate of return accounting for uncertainty, risk, and the attitude of the investor toward risk. As illustrated in Figure 3, suppose an investor has a choice between letting a valuable tree grow at a rate of 4% per year, or cutting the tree down, selling it, and putting the money in the bank. Which decision is best depends on the rate of interest the bank pays.

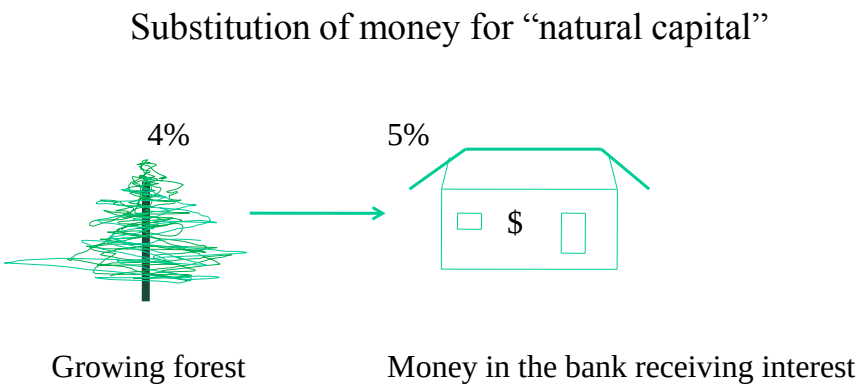

Figure 3. Whether or not to cut down the forest depends on the rate the tree is growing and the rate of interest.

If the bank pays 5% interest and the price of timber is constant, the investor will earn more money by cutting the tree down and selling it, that is, by converting natural capital into financial capital. This simple example is a metaphor for the conversion of the natural world into financial capital. The short-comings of applying this simple approach to climate change are numerous and include (1) the irreversibility of climate change affects, (2) pure uncertainty as to the effects of climate change, (3) the difference between private investment decisions made by individuals at a point in time and our responsibility to others living at different times and at different places , (4) the implicit assumption that all forms of capital are substitutable for one another, (5) the assumption that reinvestment of natural capital is possible and that future returns on the reinvestment are certain, and (6) the assumption that the change being evaluated is marginal, that is, it will not substantially alter existing economic conditions including relative prices (Hepburn 2006) . The discount rate can be seen as a reverse interest rate. In the above example, suppose the tree was not growing at all and the rate of interest on money was 6%. By not cutting down the tree and putting the money in the bank you would be losing 6% per year. This would be the discount rate on the tree in the world of financial investment.

Surprisingly, even in the most complicated formulations of neoclassical climate change models, the differences in the magnitude of the costs and benefits of climate change mitigation

are driven by the choice of discount rates (Dasgupta 2006; Nordhaus 2007; Weitzman 2007). The rate at which future costs and benefits is discounted is determined by three parameters, the social rate of time preference (Δ), the elasticity of consumption (η), and the rate of growth of per capita consumption (g).

$$r = \Delta + \eta \bullet g \qquad (3)$$

The upshot of the sometimes heated debate over the value of these parameters is that there is no scientific answer to which particular values in equation (3) should be used. A low discount rate (around 1.5% in Stern 2007 and Cline 1992) will lead to cost-benefit results favouring immediate and substantial expenditures of resources on climate change mitigation. A higher discount rate (around 3% in the Nordhaus' model) will lead to cost-benefit results indicating that only moderate mitigation polices are needed. Within the standard climate change models the three components of r determine how responsible we are for decisions today that increase our well-being at the expense of future generations. The higher the discount rate the less value we put on our negative impacts on those living in the future. It is instructive to examine in detail the factors included in the discount rate in the discounting equation and the arguments over their appropriate values.

The rate of pure time preference (Δ) is a measure of the value of the well-being of future generations seen from the perspective of those living today. A positive value for Δ means that, all other things being equal, the further into the future we go the less the well-being of persons living there is worth to us. The higher the value of Δ the less concerned we are about negative impacts in the future. A large literature exists arguing for a variety of different values for pure time preference but it is clear by now that there is no empirical way to determine the value of Δ. Choosing the rate of pure time preference comes down to a question of ethics and there is scant evidence that the discussion has moved toward resolution over the last century. Ramsey (1928, 261) asserted 80 years ago that a positive rate of pure time preference was "ethically indefensible." On the other side of the debate, Pearce (2003) took the position that a positive time discount rate is an observed fact since people do in fact discount the value of things expected to be received in the future. But even if we agree to use a market rate, which market rate should be used? U.S. market interest rates are typically used but why should these rates be the norm? Climate change will affect the entire world's population including those from cultures

with very different ideas about obligations to the future. Portney and Weyant (1999, 4) point out that "[t]hose looking for guidance on the choice of discount rate could find justification [in the literature] for a rate at or near zero, as high as 20 percent, and any and all values in between." (quoted in Cole 2008). Frederick, Loewenstein, and O'Donoghue (2004) report empirical estimates of discount rates ranging from -6% to 96,000%! Discounting from the perspective of an individual at a point in time is not equivalent to a social discount rate which should reflect the long term interest of the entire human species. A positive observed market discount rate merely shows that market goods received in the future are worth less to an individual living now, not that they are worth less to another at the point they are received in the future.

The other important factor in the Ramsey equation determining how much we should care about the future is how well-off those in the future are likely to be. The standard economic model equates well-being with consumption and, as shown in equation (3), characterizes the material well-being of future generations using two components, the growth rate of per capita income in the future (g) and the elasticity of consumption (η). The elasticity of consumption shows the percentage change in well-being arising from a percentage change in the level of consumption. If η is equal to 1, corresponding to a logarithmic utility function, then 1% of today's income has the same value as 1% of income at some point in the future. So if per capita income today is $10,000 and income in the year 2100 is $100,000, $1,000 today has the same value as $10,000 in 2100. With that income growth assumption, in the standard climate change model, a $1,000 sacrifice today would be justified only if it added at least $10,000 to the average income of people living in the year 2100 (Quiggin 2007). The higher the value of η, the higher the future payoff must be for a sacrifice today. A number of assumptions are buried in the term η. It is assumed that η is independent of the level of consumption, that it is independent of the growth rate of consumption, that only consumption increases well-being, and (usually) that its value is equal to 1 (Nordhaus 1994, Stern 2007). These assumptions are arbitrary and adopted mainly for convenience.

The climate change debate has demonstrated clearly that how much the current generation should change its behavior (which may or may not involve sacrifice) to protect future generations is a matter of ethics and best guesses as to the magnitude of future damages due to climate change. This realization had led several prominent economists to question the applicability of standard economic analysis to problems involving the well-being of distant

generations in the face of pure uncertainty and massive environmental changes. Quiggin (2007, 18) writes of the economic analysis of climate change: "The real difficulty here is that we are pushing economic analysis to its limits, in an area where fundamental problems, such as the equity premium puzzle remain unresolved. Economists can help define the issues, but it is unlikely that economics can provide a final answer."

The increasing scepticism of leading environmental economists as to the usefulness of standard theory has also led naturally to a questioning of the role of markets in solving environmental problems. Partha Dasgupta, one of the pioneers of modern environmental economics writes:

> The advances that have taken place in ecological economics in recent years have owed much to collaboration between ecologists and economists. Among those advances is a heightened awareness of the ubiquity of non-linearities in ecological processes and the inability of the price mechanism – even a complete specification of property rights – to allocate resources efficiently (Dasgupta 2008, 6).

Like many economists, Martin Weitzman is sceptical of the *Stern Review's* choice of parameter values. But he sees the Stern Review as "an opportunity for economists to take stock of what we know about this subject, how we know it, what we don't know, and why we don't know it" (Weitzman, 2007, 703).

The latest views of Weitzman (2007) and Dasgupta (2007, 2008) suggest a profound reformulation of the economic analysis of climate change. We are in uncharted waters where the costs of mitigation may be large but the cost of inaction is potentially infinite, namely the extinction of our species and a catastrophic reorganization of the earth's climate and biosphere. It is likely that the magnitude of damages from the mega-greenhouse will be so great as to lie outside the marginal effects on GDP that have been the focus of traditional models. Weitzman notes that most of the damages of global warming are likely to be unmeasured by GDP.

Weitzman's major contribution to the *Stern Review* debate is to highlight the importance of recognizing the limits of standard science in dealing with situations involving large uncertainties about the possibility of catastrophic future events. In Weitzman's view the economic analysis of global warming should be seen not a problem of smoothing consumption over time but rather determining how much insurance to provide to avoid a small chance of ruinous catastrophe.

The discounting equation above (3) may have been misused by economists, but it contains the three essential questions as to our responsibility to future generations. How should we value

the well-being of those living in the future that will be impacted by policy decisions we make today (Δ)? How well-off will those in the future be (g)? How much happier will they be made by additions to their material well-being (η)? It turns out that how people discount the future is one of the central questions that behavioral economists and neuroscientists are beginning to answer. How people discount the future is perhaps the most important ethical question in the climate policy debate. But discounting is also central to individual behavior and a key determinate of how much people are willing to move toward sustainable behavior.

To summarize, the built-in assumptions of the neoclassical model as typified by Nordhaus' dynamic, integrated climate and economy (DICE) model include:

1. Individual human well-being is measured by income and social welfare is measured by the sum of individual income. In the standard model climate change mitigation policies are justified only if they lead to a net increase in per capita consumption (income).
2. Income received in the future is discounted—future income is worth less than income received in the present.
3. The standard model is entirely static. There is no adequate description of the dynamic complexity that characterizes real economies.
4. Consumer goods (and productive inputs) are always substitutable for one another. There is nothing unique about anything that gives people utility, including a stable climate.
5. There is no notion of humans as biological creatures living within social and environmental contexts.
6. Economic agents (consumers and producers) are entirely autonomous. Consumers are not influenced by the actions or characteristics of other consumers, producers are unaffected by other producers.
7. The only value of a stable climate is its contribution to *economic* value (broadly defined).

Modifying these assumptions has proved to be very difficult, if not impossible, within the mathematics of the standard Walrasian model. In particular, the independent actor assumption turned out to be the fatal flaw in the model that opened the door for the behavioral attack on the neoclassical model.

VI. Three Game Theory Experiments

In the 1950s and 1960s the inconsistencies uncovered by Allais, Ellsberg, and others were considered to be oddities. They were thought to be interesting but irrelevant to economic theory. This began to change in the 1980s when carefully designed experiments documented the fact that "anomalies" to the rational actor model were not only widespread but actually dominated human decision making. By the turn of the twenty-first century experimental results from behavioral economics, evolutionary game theory and neuroscience had firmly established that human choice is a social, not self-regarding, phenomenon. Two broad principles emerged from the behavioral economics literature: (1) human decision-making cannot be accurately predicted without reference to social context, and (2) regular patterns of decision-making, including responses to rewards and punishments, can be predicted both within particular cultures and across cultures. These principles emerged in large part because of controlled experiments from the field of game theory. In particular, three classic game theory experiments, The Prisoner's Dilemma (PD), The Ultimatum Game (UG), and The Public Goods (PG) Game proved to be decisive in establishing behavioral regularities that contradicted the assumptions of the standard economic model.

The Prisoner's Dilemma - For many years game theory was one of the bastions of orthodoxy in economics. The classic textbook example of the inevitability of selfish behavior is the Prisoner's Dilemma. The setting for the game is this. The police have captured two people, the Gecko brothers, Seth and Quentin, suspected of committing a serious crime. The case against them is not strong so they need a confession from at least one of them. They put the two brothers in separate rooms and offer them the deal shown in Figure 4. If neither confesses they get 3 years each. If they both confess they get 4 years each. If one confesses and the other does not the confessor gets 1 year and the non-confessor gets 6 years. The way the game is framed it is "rational" for Seth or Quentin to confess no matter what the other one does. Suppose Seth confesses, then Quentin should confess in order to get 4 years instead of six. Suppose Seth does not confess, then Quentin should also confess in this case to get 1 year instead of 3. The same logic applies to Seth who should also confess no matter what Quentin does. This is called a Nash Equilibrium (named for Nobel laureate John Nash) which occurs when each player's strategy is optimal, given the strategies of the other players. A player has a dominant strategy if that

player's best strategy does not depend on what other players do (as in the prisoner's dilemma – always confess).

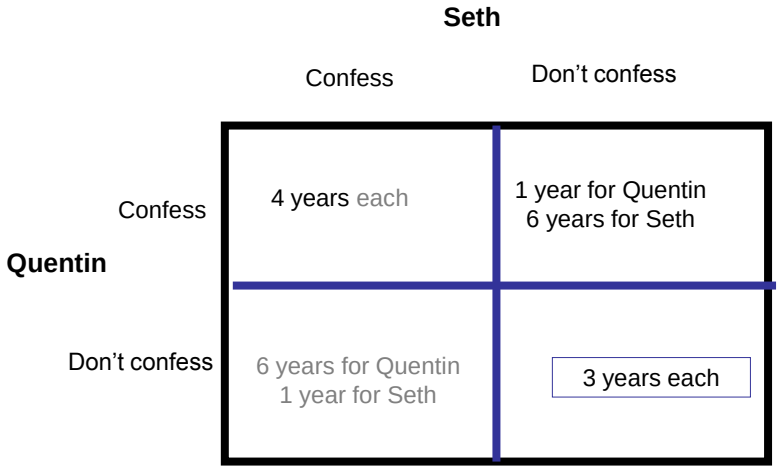

Figure 4. The Prisoner's Dilemma

The theoretical result of the PD game, no cooperation, is based on the assumption that there is no interaction between the two players. But in repeated PD games people tend to cooperate. That is, after two players become accustomed to playing with each other a degree of trust develops so that they cooperate to get lighter sentences. More surprisingly, even in one-shot anonymous PD experiments, over one half of the players cooperate (Field, 2001). Among the first two people to play the game in the 1950s were the imminent economist and mathematician Armen Alchian and John Williams, a distinguished mathematician at the Rand Corporation. When they cooperated in the one-shot PD game John Nash remarked, "I would have thought them more rational" (quoted in Field, 2001).

The Ultimatum Game - One of the most important contributions to behavioral economics was the Ultimatum Game (UG) formulated more than twenty-five years ago by Güth, Schmittberger and Schwarz (1982). In the Ultimatum Game a leader offers one of two participants a certain sum of money and instructs that participant to share it with the second player. The second player can either accept the offer or reject it in which case neither player gets anything. If the players

behave according to model of *Homo economicus*, the first player should offer the minimum amount and the second player should accept any positive offer. More should always be preferred to less no matter what the social context is. Results from the UG game show, however, that the majority of proposers in Western countries offer between 40% and 50% of the total and that offers under 30% of the total are usually rejected because they are not "fair" (Nowak, Page and Sigmund, 2000). These results have held up even when the game is played with substantial amounts of real money (Gowdy, Iorgulescu, and Onyeiwu, 2003).

Like the PD game before it, the UG helped revolutionize the way economists think about economic decision making. Results from this game, as well as from a variety of other game theoretic experiments, showed that, in a variety of settings and under a variety of assumptions, other-regarding motives are a better predictor of behavior than those embodied in *Homo economicus*. Humans regularly exhibit a culturally-conditioned sense of fairness and they are willing to enforce cultural norms even at economic cost to themselves. This is called *altruistic punishment*. Cross-cultural UG experiments also show that cultural norms vary and that they dramatically affect the average amount offered in the game and the rates of rejection (Henrich et al. 2001). A striking result of numerous UG experiments is that the model of rational economic man is not supported in any culture studied. Henrich et al. (2001, 73-74) summarize the results of behavioral experiments in 15 small-scale societies ranging from hunter-gatherers in Tanzania and Paraguay to nomadic herders in Mongolia:

> We can summarize our results as follows. First the canonical model is not supported in any society studied. Second, there is considerable more behavioral variability across groups than had been found in previous cross-cultural research, and the canonical model fails in a wider variety of ways than in previous experiments. Third, group-level differences in economic organization and the degree of market integration explain a substantial portion of the behavioral variation across societies: the higher the degree of market integration and the higher the payoffs to cooperation, the greater the level of cooperation in experimental games. Fourth, individual-level economic and demographic variables do not explain behavior either within or across groups. Fifth, behavior in the experiment is generally consistent with economic patterns in everyday life in these societies.

The Public Goods game - Another standard game is the public goods game. This game has many variants but a typical version goes something like this. There are ten players and they play the game for ten rounds. On each round each player is given the choice of depositing some amount

of money (say 50¢) in "community pool" or keeping a larger amount for himself (say $1). If he deposits 50¢ in the common pool, he and the nine other players get 50¢ each. So if all players are cooperative then each player receives $5 per round (10 X 50¢) for a total of $50 at the end of the ten round game. If all players are selfish they only get $1 per round or $10 at the end of the game. The catch is that if one player acts selfishly and the other players cooperate, the selfish player gets $5.50 per round (9 X 50¢ + $1) and all the others get $4.50 (9 X 50¢). So it pays to be a defector (free rider) if the rest of the players cooperate. Standard welfare theory predicts that "rational" players would never cooperate and that each player would take $1 for him or herself starting with round one of the game. But results of public good games show much more complicated behavior. Typically the majority of players begin by cooperating but then they change their behavior to defecting when they see others being selfish. If the game is played many times people build up a sense of trust and there is a return to cooperation. If players are allowed to punish free riders by fining them the game usually evolves to a cooperative outcome (for a summary of PG games see Gintis 2000b, Chapter 11).

Results from the ultimatum game, the public goods game, and other game theoretic experiments show that, in a variety of settings and under a variety of assumptions, other-regarding motives are a better predictor of behavior than those embodied in self-regarding *Homo economicus*. Humans regularly exhibit a culturally-conditioned sense of fairness and they are willing to enforce cultural norms even at economic cost to themselves.

VII. Some Key Findings from Behavioral Economics and Neuroeconomics

If the neoclassical assumptions about human behavior (transitivity, non-satiation, strictly rational behavior) are untenable, where do we go from here? Is it possible to construct a model of human behavior consistent across disciplines to inform economic theory and policy? The answer is a tentative "yes." A number of empirical findings and behavioral regularities have been identified and these are beginning to be used to inform public policy.

1. Emotions are not "irrational", they are essential to decision-making in humans. The standard view is that people strive to make rational decisions but are sometimes thwarted by their emotions. By contrast, the emerging view of cognition is that the human brain it is a unified, highly evolved system with complementary, rather than conflicting (rational and emotional),

components. Referring to the idea of some economists that "irrational" behavior is the product of ancient emotional systems within the brain, Glimcher, Dorris and Bayer (2005, 252) write:

> What we cannot stress strongly enough is that the vast majority of evolutionary biologists and neurobiologists reject this view. There are probably two principle reasons that biologists reject this dualist view of the nervous system; one neurobiological and one behavioral. First there is no neurobiological evidence that emotional and non-emotional systems are fully distinct in the architecture of the human brain. Second there is no evidence that rational and irrational behaviors are the products of two distinct brain systems, one of which is uniquely rational and one of which is uniquely irrational.

Studies have shown that some people with neurological damage to the emotional part of the brain are incapable of making even simple decisions even though they can clearly describe the problems they are asked to solve and the consequences of each possible decision. More surprisingly, people with damage to a part of the brain called the *ventromedial prefrontal cortex* act like "rational economic men." For example, most people would have difficulty making the following choice: "You know that a carrier of a deadly airborne strain of Ebola is about to board a plane where he will share the same stale air with scores of strangers. Do you allow him to risk infecting fellow passengers or do you kill him if that is the only way to prevent him from getting on the flight?" (Swaminathan 2007) Yet people with brain damage have no problem in answering the question. They would make the rational, utilitarian decision and kill the passenger.

> …[W]hen people are confronted with ambiguity their emotions can overpower their reasoning, leading them to reject risky propositions. This raises the intriguing possibility that people who are less fearful than others might make better investors, which is precisely what George Loewenstein and four other researchers found when they carried out a series of experiments with a group of patients who had suffered brain damage. Each of the patients had a lesion in one of three regions of the brain that are central to the processing of emotions… The researchers presented the patients with a series of fifty-fifty gambles, in which they stood to win a dollar-fifty or lose a dollar. This is the type of gamble that people often reject, owing to loss aversion, but the patients with lesions accepted the bets more than eighty per cent of the time, and they ended up making significantly more money than a control group made up of people who had no brain damage (Cassidy 2006).

2. There is no sharp distinction between "brain", "mind", and "society. One of the most remarkable findings from neuroscience is the importance of socialization in human brain development. According to Brian Wexler (2006) two important ideas have emerged from new knowledge about the sensitivity of the human brain to social inputs. The first is the incredible

diversity and variability among individuals resulting from environmental influences on brain development. Wexler (2006, 3) writes:

> There is an evolutionary advantage for life forms that reproduce sexually because mixing of genetic material from parents produces variety in their offspring. Thus, different individuals have different characteristics, which increases the likelihood that some members of the group will be able to function and reproduce even when the environment in which the group lives changes. In an analogous manner, the distinctive postnatal shaping of each individual's brain function through interaction with other people, and through his or her own mix of sensory inputs, creates an endless variety of individuals with different functional characteristics. This broadens the range of adaptive and problem-solving capabilities well beyond the variability achieved by sexual reproduction.

It has long been realized that human are unique in the length of time required to raise a child to maturity. Neoteny, the characteristic of retaining juvenile features, may function in humans to extend prenatal development after birth.[3] Again quoting Wexler (2006, 98):

> Infancy and childhood last much longer in humans than in other mammals, allowing greater influence of these social interactions on brain development. The process through which such interactions have their effects has been well studied, albeit more descriptively rather than experimentally. Several distinct but overlapping and interacting processes have been described: instrumental parenting , turn taking, imitation, identification, internalization, and play. These processes are the basis for the long-lasting effects of the social environment on development of the human brain, the sensitivity of humans to change in their environment in general and their social environment in particular, and the great efforts humans will make to maintain consistency in their environment.

The human brain continues to develop neurologically for years after birth and the way it develops depends critically on how a child is socialized. It is another way that variability can be introduced into evolutionary mix. This also provides a sort of microfoundation to Richerson and Boyd's (2005) argument that large brains were an evolutionary advantage for humans during the extreme climate volatility during ice ages. The ability to adapt customs and technology to changing conditions allowed humans to successfully compete for food resources with animals that depended on more purely genetic adaptation mechanisms.

Wexler's second insight into human brain development is even more important for climate change adaptation and climate change policy. Humans alter the environment that shapes brain development to an unprecedented degree. Wexler (2006, 3) writes:

> These human alterations in the shared social environment include physical structures, laws and other codes of behavior, food and clothes, spoken and written language, and music and other arts…It is this ability to shape the environment that in turn shapes our brains that has

> allowed human adaptability and capability to develop at a much faster rate than is possible through alteration of the genetic code itself.

Most of the world's population (although certainly not all) live in a material environment almost entirely created by humans. Very little of our well-being comes directly from the natural world (although ultimately, of course, it all does). We have adapted technologically, socially, and even neurologically to a human world insulated from the ultimate effects of our activities on the earth that supports us. For most of us climate change is something in the distant future affecting people in distant lands. But again, the good news is that humans have an unrivaled ability to adapt to new situations and meet new challenges. The importance of post-natal brain development in humans means that we have the innate ability to change our attitudes and ways of living both to reduce our pressure on the environment and to adapt to the inevitable changes we have set in motion. The evolution of our "social brain" (Grist 2009) means that pure altruism can exist and override egoism for the good of the group.

3. Most of our daily decisions are made unconsciously. Rational deliberation is a costly, time consuming process. The human brain has a variety of ways to conserve on thinking and this has important policy implications. One of the most relevant is the difference between "opt-in" or "opt-out" choices. For example, consider the statistics for different countries on organ donations.

Table 1. Percent of Drivers Donating Organs

Denmark	4%
Netherlands	28%
United Kingdom	17%
Germany	12%
Austria	100%
Belgium	98%
France	100%
Hungary	100%
Poland	100%
Portugal	100%
Sweden	86%

Source: youtube presentation by Dan Ariely at http://www.youtube.com/watch?v=JhjUJTw2i1M

What accounts for the vast differences in donation rates in countries that are otherwise quite similar? The answer is simply that people in the first four countries listed in table 1 are asked the question on their driver's application "Check the box below if you *want* to participate in the organ donor program." People in the other countries were asked the question "Check the box below if you *do not want* to participate in the organ donor program." We like to think of ourselves as rational decision makers in control of the choices we make. But in effect the person who designed the questions is really the one who made the choice about organ donations. Organ donation is a rather complicated moral decision and we would prefer not to think too much about it, so the fall-back, do-nothing-active choice is appealing.

4. Habituation and heuristic short-cuts are important in human decision-making. The process of learning involves familiarizing ourselves with new information to the extent that we no longer have to consciously think about it when it comes up. We make most decisions based on past experience. Habituation also has a neurological basis. It has long been known that two groups of neurons, in the *ventral tegmental* and the *substantia nigra pars compacta* areas, and the dopamine they release, are critical for reinforcing certain kinds of behavior (Schultz, Dayan and Montague 1997; Glimcher, Dorris and Bayer 2005). Schultz (2002) measured the activity of these neurons while thirsty monkeys sat quietly and listened for a tone which was followed by a squirt of fruit juice into their mouths. After a period of a fixed, steady amount of juice, the amount of juice was doubled without warning. The rate of neuron firing went from about 3 per second to 80 per second. As this new magnitude of reward was repeated, the firing rate returned to the baseline rate of 3 firings per second. The opposite happened when the reward was reduced without warning. The firing rate dropped dramatically, but then returned to the baseline rate of 3 firings per second.

Humans become habituated both to higher levels of reward and lower levels. Again, for public policy considerations this has good and bad consequences. Consider the case of consumption. Consuming market goods can be a kind of addiction that requires ever increasing amounts to give us a constant level of satisfaction. On the other hand, another implication is that we can also get used to lower levels of material consumption and be just as happy as before.

5. Altruism and Group Selection

One of the most important revolutions in biology in recent years has been the wide-spread acceptance of group selection (Sober and Wilson 1998, Wilson and Wilson 2008). For a long time it was thought that any individual that acted for the good of the group would jeopardize its own survivability and thus such behavior would be quickly weeded out by natural selection. Wilson and Wilson (2008, 390) write:

> Prudently managing a shared resource benefits all members of a group, including any "cheaters" who consume more than their share. Genes associated with cheating would therefore spread throughout the group, and the propensity for cooperative resource management would be undermined. The situation is all too familiar in human experience; it is the phenomenon that Garret Hardin famously named "the tragedy of the commons."

In the 1970s many economists became enamored with the "selfish gene" idea in biology (Dawkins 1976). It seemed to offer a "natural", "scientific" justification for rational economic man and for free market economic policies (Manner and Gowdy 2009). At that time theories of group selection in biology were in disfavor because there seemed to be no way around the fact that altruistic behavior made an organism less fit compared to its non-altruistic competitors. But gradually biologists came to realize that pure altruism could emerge if such behavior gave a competitive advantage to a particular group. Price (1970, 1972) presented a mathematical formula that decomposed changes in gene populations into two effects; between group and within group selection. If competition existed between groups, then individual behavioral traits that conferred an advantage to the group could be selected. Once it was established that cooperative behavior (pure altruism) could have an evolutionary advantage, theories of group selection once again became acceptable to biologists (Wilson and Hölldobler 2005).

Group selection refers to a process of natural selection that favors traits that increase the fitness of one group relative to other groups (Wilson 2005). Every member of the group depends on a common characteristic not isolated in a single individual. Such behavior is the result of Darwinian "selection" but not selection rooted solely in the characteristics of individuals (Richerson and Boyd 2005). Group selection depends on *other-regarding interaction* among individuals, and is thus incompatible with isolated, self-referential interaction between cultural and genetic transmission. In social animals, natural selection is more likely to favor pro-social behavior than the selfish gene model would predict. Henrich (2004) notes that a purely genetic approach cannot explain the degree of pro-social behavior observed in humans. He suggests that

a co-evolutionary process between cultural and genetic transmission is at work. Using a group selection perspective we can pose a scientific explanation for the cooperation and fairness observed in large groups and among unrelated strangers in non-repeated contexts. Given the genetic homogeneity of the human species, the wide variation in degrees of cooperation observed in human societies points to a cultural origin. In addition, if the large scale cooperation often observed in humans was purely based on genetic natural selection one would anticipate it would be more widespread in nature. Henrich (2004, 30) suggests:

> …rooting the development of large-scale cooperation in the details of human social learning, addresses this challenge. Other mammals do not cooperate to the degree humans do because they lack the social learning abilities that produce cultural evolution and behavioral equilibria not available to genetic transmission alone.

Bands of early humans competed against each other for scarce resources and those bands that were more cohesive most likely had a survival advantage. Wilson (2005) regards the distinction between absolute and relative fitness as essential to understanding the impact of group selection. By increasing the absolute fitness of individuals within a single, isolated group (or population) to the same degree, their relative fitness does not alter, so that the fitness change will be without evolutionary consequences. But when adding other groups that interact (perhaps depending on the same scarce resources), the absolute change in fitness for the original individuals will mean an improved average fitness of the group relative to that of other groups. Then the group may grow more quickly than other groups and thus will increase its proportion in the total population. Wilson notes that explanations based on individual-level selection tend to neglect the possibility of group selection effects because they focus on absolute instead of relative fitness improvements. He notes that by changing strategy individuals may reduce their relative fitness even if they improve their absolute fitness, simply because the group as a whole benefits from their change of strategy, as in the case of altruistic acts (van den Bergh and Gowdy 2009).

6. A sense of fairness is a universal human attribute although notions of fairness differ across cultures. Results from game theory and behavioral economics show that preferences are other-regarding. People act to affect the well-being of others, positively or negatively, even at significant cost to themselves (Fehr and Gächter, 1999). A sense of fairness, including pure altruism, is a critical factor in economic decisions. This is illustrated in various game theory

experiments such as the public good game in which participants are willing to impose, at great cost to themselves, punishments on non-contributors, even in the last round of the game (Bowles and Gintis 2002). These kinds of behavior patterns have important consequences for judgments about human well-being and environmental policy design.

According to the biologist Alexander (1987), the evolution of ethics received a major stimulus from the long history of violent interactions among ancestral primate groups, and in line with this was aimed at strengthening the structure of the own group. This is supported by asymmetric behavior in conflicts among (living) apes and monkeys: conflict resolving inside the group, and extreme brutality to outsiders. Similarly, humans apply ethics asymmetrically to insiders and outsiders of the group they belong to. The most convincing examples of this are wars and religious and ethnic conflicts (de Waal 1996, 29; Wilson 2002). In a recent study, Choi and Bowles (2007) invoke a group selection model to show that group conflict between humans may be closely related to the evolution of altruism and a sense of what is fair and unfair. The latter has two faces, namely providing benefits to fellow group members and showing hostility towards outsiders, both at a personal cost. Field (2004, 8) phrases it as: "… the ability to make common cause has a dark side: the control of within group conflict sometimes lays the foundation for violent attacks on outgroups. But the inclination is also what brings millions of people to the polls in democratic nations and is as much an underpinning of democracy as it is of totalitarianism."

7. Time Inconsistency and Hyperbolic Discounting

Time consistency is critical to the standard economic assumption that benefits delivered in the future should be discounted at a fixed rate. But behavioral studies indicate that people discount the near future at a higher rate than the distant future and they have different discount rates for different kinds of outcomes (Frederick, Loewenstein and O'Donohue 2004). This is called hyperbolic discounting and, as shown in
Figure 5, the discount rate declines then flattens out so that after some time the present value of income received in the future does not continue to decrease.

The existence of hyperbolic discounting implies that standard economic analysis may seriously underestimate the long-term benefits of climate change mitigation policies. If people discount hyperbolically, and if we respect stated preferences, straight-line discounting should not

be used to place values on distant-future environmental damages such as those caused by abrupt climate change. Hyperbolic discounting has been widely discussed in the theoretical literature and has had some impact on policy recommendations. Cropper and Laibson (1999) recommend using hyperbolic discounting in the case of global warming and Chichilnisky (1996) uses hyperbolic discounting in her model of sustainable development. One of the positive features of welfare economics is that, in theory, it respects individual choice. If individuals choose to place the same value on biodiversity present 50 years from now as they do on biodiversity 100 years from now, then economists should respect that preference.

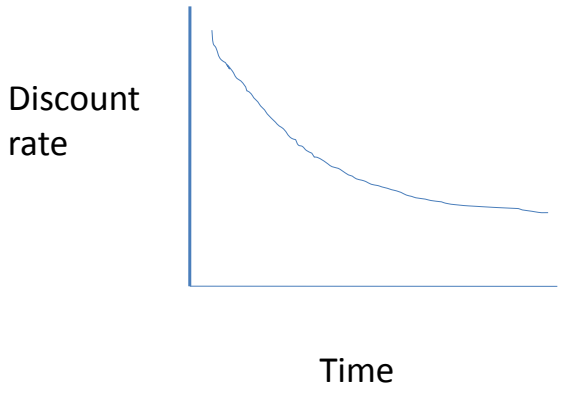

Figure 5. Hyperbolic discounting

Rubinstein (2003) points out that hyperbolic discounting has been accepted by many economists because it can be easily incorporated into the net present value framework of standard economic analysis. He argues that the evidence suggests that the larger problem is inconsistent, not hyperbolic, discounting. People appear to have different discount rates for different kinds of outcomes. Considerable evidence exists that people are wildly inconsistent even when discounting similar things. Inconsistent discounting suggests that there may be limits to attempts to placing precise numbers on the general tendency of individuals to prefer something now rather than later.

Anticipation has been found to be a positive thing in itself and may result in something in the future actually having a *higher* value (Loewenstein 1987). This finding is relevant to environmental policies such as preserving national parks and other wildlife areas because individuals may enjoy them more in the future (after retirement, for example) and the anticipation of this is important.

8. The status quo bias, the endowment effect and prospect theory – One of the first behavioral challenges to *Homo economicus* came from Kahneman and Tversky (1979) in their formulation of "prospect theory", that is, people evaluate changes in terms of a reference point. Anchoring is similar to prospect theory but a little more subtle. Researchers have discovered that estimates of probabilities (or payoffs) are related to immediate cues that "irrationally" influence valuation. It seems to be a psychological law that people prefer something they already have to something they do not have (Kahneman and Tversky 1979). In a classic experiment by Jack Knetsch (1989) students in three classes were given the choice between a coffee cup and a chocolate bar. Students who were initially given a mug or a chocolate bar overwhelmingly chose to keep whichever one they were given. Those who were offered a choice at the end of the experiment had no clear preference. Tests of the endowment effect have shown that it is not due to wealth effects, income disparities, strategic behavior or transactions costs (Knetch 1989).

9. Loss Aversion

One of the first behavior-based challenges to neoclassical economics came from Maurice Allais in the early 1950s in the form of the *Allais paradox* (Allais 1952). Using an example based on loss aversion Allais demonstrated the inconsistency of actual consumer choices and the predictions of expected utility theory. The explicit assumption in economic analysis is that only the absolute magnitude of the change matters, not the direction of the change. But the behavioral pattern is that people are more concerned about avoiding losses than they are about acquiring gains is well documented (Knetsch and Sinden 1984). The hypothesis that losses are systematically valued more than equivalent gains has been verified in numerous experiments. These experiments show that preferences depend on the direction of the change, that is, whether people are paid to give up something they have, or have to pay to get something they do not have. The psychological model makes good predictions of economic behavior; the rational actor model does not.

The neurological basis for loss aversion was confirmed by Tom et al. (2007). They found that in order for people to accept a 50-50 gamble the potential gain needs to be twice as high as the potential loss. They discovered that the brain regions that evaluated potential gains and losses were more sensitive to losses. Also, between-subject differences in loss aversion reflected between-subject differences in neural responses.

Loss aversion is one reason for the widely reported discrepancy between willingness to pay for a gain (WTP) and willingness to accept a loss (WTA) measures of environmental changes (Brown and Gregory 1999). Estimates of WTA a loss of something are typically several times greater than WTP for the gain of the same item. The implications for evaluating the costs of climate change are profound. Even in the context of standard utility theory, the required compensation for climate change damages (WTA) is likely to be much greater than the estimated market value of that loss (WTP).

There is most likely an evolutionary basis for loss aversion. Early humans were more likely to survive if they avoided potentially dangerous situations even if the expected payoffs were high. Humans are content to "satisfice" rather than "optimize" (Simon 1987).

10. "Them and Us" - Herd Behavior and Group Selection

The human ability to cooperate with unrelated others is unique among mammals. But the groupishness of humans also has a dark side. Humans are also unique in their ability to inflict the most unimaginable atrocities on members of their species they classify as "others." A strong case can be made that this has an evolutionary basis. For most of our existence humans lived in small bands of hunter-gatherers in competition with other, similar bands. Boehm (1997) argues that those bands that had a stronger social cohesion were able to out-compete other less cohesive bands. This group selection process became even stronger with the advent of large-scale societies after the wide-spread adoption of agriculture some 8,000 years ago. Boehm argues further that human institutions had a great impact on human evolution. David Sloan Wilson (2002) argues that organized religions may be the result of evolutionary selection because of its almost unique ability to strongly bond together unrelated individuals.

David Berreby (2005, chapter 8) describes a remarkable experiment illustrating both the negative consequences of "them and us" behavior and also the ability of humans to redefine these categories. In 1954 Muzafer Sherif[2] and his colleagues at the University of Oklahoma

conducted an experiment in group behavior at Robbers Cave camp in the mountains of eastern Oklahoma (Sherif et al. 1961). Twenty-two middle class Caucasian boys enrolled in Oklahoma schools were divided into two groups of eleven boys each. Each group was assigned to a particular area with its own bunkhouse, mess hall, and swimming hole. Each group was given the freedom to explore the area and organize itself as the group members chose. The groups chose names ("Rattlers" and "Eagles"), designed their own logos, and constructed various behavioral rules that established their own identities. During the first week each group was unaware of the existence of the other group.

After the first week each group was made aware of the other group. The reaction of each group toward the other was immediate and negative. Berreby writes:

> Among both bands, talk of "our" swimming spot and "our" field sprung up only after the boys knew there was another gang nearby. The feeling extended to everyone; fishermen and hikers passing through the state park would also cause the boys to fret about interference with "our" territory. Their passionate sense of Eagleness and Rattlerdom was marking the entire human world (Berreby 2005, 170).

A week of arranged competition between the groups (baseball games, tug-of-war contexts) made the rivalry between the two groups more intense and the sense of us versus them even more pronounced.

> Fourteen days after they had arrived as strangers, then, these look-alike boys, all born around the same time, from look-alike households, had turned into two exclusive disdainful tribes, yelling "dirty bums" and "sissies" at their neighbors whenever their paths crossed. It had all been "experimentally produced from scratch" as Sherif put it (Berreby 2005, 173).

At this point the results of the Robbers Cave experiment are discouraging. It seems that it is "human nature" to automatically coalesce into hostile camps each with its own rules of conduct and defining characteristics of what is correct and incorrect behavior. "Bad" human nature dominates our best intensions. But the third week of the experiment shows that the story of "us and them" is not so bleak as popularly imagined.

During the third week Sherif initiated what he deemed to be the main objective of the experiment, namely, to disprove the "original sin" view of human nature. Sherif initiated a number of activities that required the two groups to work together—repairing a broken faucet, raising money to rent a movie, getting a disabled truck going again. After a week of working

together to solve common problems, the transformation of the "us-them" mentality was remarkable:

> The last night, the boys decided they wanted to go to the camp's corral, where they roasted marshmallows. Then each group performed skits for the other. The next day was the last of the camp. At breakfast and lunch, the boys sat higgledy-piggledy, with no regard for Rattlerdom and Eagleness. The frequent opinion polls he was taking also told Sherif that attitudes were changing: overwhelmingly hostile sentiments about "the others" had been replaced by overwhelmingly positive feelings. Meanwhile, the bands' ratings of their members had gotten somewhat less enthusiastic. It was as if the need to puff up their members had quieted, along with the urge to disparage the enemy. When they took seats on the bus for the trip home that afternoon, the boys ignored Rattler-Eagle lines completely (Berreby 2005, 176-177).

Human history is full of accounts of horrible atrocities perpetuated by one group upon another. These groups may be based on real physical or ideological differences or they may be almost entirely arbitrary as in the Robbers Cave experiment. The good news is that the "us-them" distinction is always arbitrary and can be changed through communication, increasing familiarity with out-group members, and the presence of some common challenge affecting all groups.

11. Social Norms and Process Regarding Preferences

People care about process as well as outcome. In designing economic policies the process of arriving at a decision may be as important for public acceptance as the actual outcome itself. For example, results from the ultimatum game (mean offers and rejection rates) vary significantly according to the process through which money is obtained and the way offers are made. Offers are substantially lower if proposers win their position by doing well on a quiz (Hoffman et al., 1994). Rejection rates are much lower if respondents are told that the offers were generated by a computer. In the prisoner's dilemma game, defection rates are significantly higher if the game is referred to as the "Wall Street Game" rather than the "Community Game." Results from these and numerous other studies in game theory, experimental economics, and behavioral economics show that models that do not take into account social processes such as community norms about fairness may lead to poor predictors of economic behavior.

Biased cultural transmission is a theory of innovation diffusion based on the observation that people imitate others whose actions they trust or respect. People use heuristics, mental shortcuts and rules of thumb, to make otherwise complicated decisions. Biased cultural

transmission may lead to the widespread adoption of economically inefficient ways of doing things. By *selectively* imitating respected individuals, people may insure that innovations become established in a community whether or not the innovation is superior to others as determined by cost-benefit calculations (Henrich 2003). The important factor in adoption is the innovation's conformance with established cultural patterns. This has far-reaching implications for the design of economic policies.

12. The Framing Effect

Consistency in choice is the hallmark of rational economic man and it implies that the evaluation of choices will be unaffected by the manner in which the choices are framed. The "framing effect" means that the frame of reference may change according to how a particular choice is presented and this will affect the payoff decision. This effect has been confirmed in numerous other experiments and it too seems to have a neurological basis (Miller 2006). De Martino et al. (2006) used functional magnetic resonance imaging (fMRI)[1] to look at the neurological effects of framing in a simple experiment. A group of 20 subjects in the United Kingdom were asked to choose between identical outcomes framed differently. They were told first that they would initially receive £50. They then had to choose between a "sure" option and a "gamble" option. The sure option was presented in two ways, either as a gain (say keep £20 of the £50) or as a loss (say lose £30 of the £50). The gamble option was presented in the same way in both cases—a pie chart showing the probability of winning or losing. People responded differently depending on how the question was framed and this was reflected in fMRI images. Different parts of the brain lit up depending on how the question was framed.

The fact that the framing effect found in this experiment had a neurological basis was confirmed:

> Our data provide a neurobiological account of the framing effect, both within and across individuals. Increased activation in the amygdale was associated with subjects' tendency to be risk-averse in the Gain frame and risk-seeking in the Loss frame, supporting the hypothesis that the framing effect is driven by an affect heuristic underwritten by an emotional system. (De Martino et al. 2006, 686)

Neurological findings may or may not add anything new to the catalog of behavioral patterns observed by behavioral economics, but they do show that they are more than "anomalies". These observed behaviors are not random mistakes but rather are a part of our neurological inheritance.

Two Other Interesting Behavioral Studies

Several other behavioral regularities have been identified but they are not so well-established. Nevertheless they are particularly interesting and relevant to climate change policy.

The Licensing Effect

An interesting study reported in *Nature* (xxx,) found that "green shopping" actually increased selfish behavior. Students at the University of Toronto were first asked to buy a collection of products deemed to be either environmentally friendly or conventional. Some students picked the "green" products while others picked the regular products. The students then played a game in which they were given the opportunity to allocate money between themselves and someone else. Surprisingly, students who had bought green products were less willing to share than those who had bought conventional products. This is called the "licensing effect". Socially responsible behavior can establish the moral credentials that allow a person to engage in less responsible behavior later.

Social Crowding out by Monetary Incentives

A growing body of experimental evidence indicates that monetary incentives can be a deterrent to cooperative behavior (Frey 1997, Frey and Oberholtzer-Gee 2002). An often cited example is the finding that paying blood donors significantly reduces blood donations (Titmus 1971). A recent experiment found that the mere mention of "money" had a negative effect on sociality. Vohs, Mead and Goode (2006) performed several experiments which compared various kinds of social behavior in groups of people that were first given reminders of "money" with groups given a "non-money" reminder. For example, in one experiment participants were asked to unscramble jumbled words to make phrases. In the money group the phrases involved some concept of money, like "a high-paying salary is important." In the control group the phrases were neutral, like "it is cold outside". This reinforced thinking in terms of money in the

experimental group but not the control group. The groups were then subjected to nine experiments designed to test the effects of exposure to money on "self-sufficiency" and helpful behavior. In one experiment subjects were given $2 in quarters which they were told was left over from an earlier experiment. At the end of the word scrambling game they were offered the chance to put money in a box to denote to needy students. Those exposed to reminders of money gave substantially less to the charity. In another experiment subjects reminded of money were less likely to ask for help in performing a complicated task. In another test, subjects were asked to sit at desks and fill out a questionnaire. Some desks faced a poster with a picture of money, and others faced a poster showing flowers or a seascape. They were then asked to choose between a reward characterized as a "group" or "individual" activity, for example, individual cooking lessons versus a dinner for four. Those exposed to the money poster were more likely to pick individual activities. The authors summarize the results as follows:

> Relative to participants primed with neutral concepts, participants primed with money preferred to stay alone, work alone, and put more physical distance between themselves and a new acquaintance…. When reminded of money, people would want to be free from dependency and would also prefer that others not depend on them" (Vohs, Mead, and Goode, 2006, 1154).

Behavioral responses like these, point to the importance of carefully considering the unintended consequences of climate change policies. The overriding lesson of behavioral and neuroeconomics is that the human brain is a complex system geared to surviving in a social world. To be "rational" is to make correct choices in particular social contexts with fluid and ever-changing rules of behavior.

VIII. Happiness and Income

As discussed above, most economic models, including climate change models, assume that social well-being can be equated to per capita income. Psychologists have long argued that well-being derives from a wide variety of individual, social and genetic factors. Economists came to the issue later but significant contributions have been made by Easterlin (1974), Frank (1999), Frey (1997), and Layard (2005). Recently (September 2009) a report commissioned by the government of France and headed by Nobel laureates Joseph Stiglitz and Amartya Sen called for the abandonment of "GDP fetishism" and the use of an array of social and environmental

indicators as a guide to public policy. As Stiglitz pointed out, the Report of the Commission on the Measurement of Economic Performance and Social Progress, was made even more timely by the financial meltdown which laid bare the ephemeral nature of financial accounting. According to Stiglitz "A focus on the material aspects of GDP may be especially inappropriate as the world faces the crisis of global warming. Should we 'punish' a country—in terms of our measure of performance—if it decides to take some of the fruits of the increase in productivity from the advancement of knowledge in the form of leisure, rather than just consuming more goods? " (quoted in Kolbert 2009).

The increasingly high level of rigor of experimental psychology has helped to make the idea of direct measures of utility acceptable to economists. Methods have been devised and tested and calibrated to accurately measure levels of happiness across individuals and even across cultures. We are now closer than anyone could have imagined to developing something like Bentham's "hedonometer" providing a cardinal measure of social well-being.

What makes people happy? Surveys, behavioral experiments, and neurological analysis have identified key factors positively influencing well-being. These include health (especially self-reported health) (Ferrer-i-Carbonell and van Praag 2002), close relationships and marriage, intelligence, education, and religion (Frey and Stutzer 2002). Age, gender and income also influence happiness, but not to the degree once thought. Some "stylized facts" about income and happiness have been established. First, people in wealthier countries are generally happier than people in poorer countries (Diener, Diener, and Diener 1995). But even this correlation is weak and the happiness data shows many anomalies. For example, some surveys show that people in Nigeria are happier than people in Austria, France and Japan (Frey and Stutzer 2002, table 2.2, p. 35). Second, past a certain stage of development, increasing incomes do not lead to greater happiness. For example, real per capita income in the U.S. has increased sharply in recent decades but reported happiness has declined (Blanchflower and Oswald 2000, Lane 2000, Meyers 2000). Similar results have been reported for Japan and Western Europe (Easterlin 1995). Studies of individuals also show a lack of correlation between increases in income and increases in happiness (Frey and Stutzer 2002). Third, security seems to be a key element in happiness. Large welfare gains would come from a focus on improving welfare based on those things that increase individual security like health insurance, old age security, employment and job security. Fourth, mental health is a crucial factor in happiness. Frey and Stutzer (2002) and

Layard (2005) argue, based on happiness survey results, for more public spending on mental health, especially for the very young since apparently the first few years of a person's life play a large role in their future happiness. If we want future generations to experience a high and sustainable level of welfare, we are likely to get high rates of return by investing in policies to insure adequate child nutrition, health care, education, and family counseling. Fifth, richer social relationships generally make people happier. This implies that welfare gains may be obtained from increased leisure time, and more public spending on social and recreational infrastructure. All of this research implies that the focus on GNP growth as a means to increase welfare may be misplaced. Ng (2003, 307) has demonstrated that analyzing preferences while ignoring the larger objective of welfare or happiness introduces a systematic materialistic bias:

> Such a bias, in combination with relative-income effects, environmental disruption effects, and over-estimation of the excess burden of taxation, results in over-spending on private consumption and under-provision of public goods, and may make economic growth welfare-reducing.

What are the implications of all this for climate change policy? There is some evidence that when individuals are more secure financially (not necessary wealthier) they are more likely to care about the well-being of future generations and the well-being of the environment. Rangel (2003) argues that social security is good for the environment. Several of the economic security increasing policies discussed above—providing health care, job security, and a minimum income—may be classified as "backward generational goods." These goods play a crucial role in sustaining investment in "forward intergenerational goods" such as environmental preservation. So it seems that focusing policies on subjective indicators of happiness, rather than on per capita income, would pay a double dividend. People would be happier and also more willing to support polices promoting environmental sustainability. Welsch (2002) uses reported well-being for 54 countries to estimate a hedonic indicator of the trade-off between environmental quality and per capita income. Welsch's study is path-breaking in that it takes self-reported happiness as an indicator of welfare, and treats per capita income as an explanatory variable. Welsch finds support for the hypothesis that specific forms of pollution are negatively related to well-being. Johansson-Stenman, Carlsson, and Daruvala (2002) found that, not only are people averse to inequality, risk, and a decline in relative standing, the social marginal utility of income may turn negative even at non-extreme income levels. Regarding the environment there is considerable

evidence that at least some people hold non-anthropocentric ethical views (Johansson-Stenman 2002).

Focusing policy on well-being rather than per capita consumption might have important positive implications for sustainability. But even if sustainable welfare policies are based on scientifically measured "preferences" this leaves us with the problem that it may not insure the preservation of the life support systems of the planet. Examples abound of societies that apparently worked well in satisfying the preferences of their citizens but ended in ecological collapse (Brander and Taylor 1998). Humans get subjective well-being from nature but this does not insure that individuals living today will choose to preserve those features of nature that may be essential to future generations. Viewing the essential life support systems of the planet as mere inputs into a utility function, no matter how broadly defined, denies the basic biophysical nature of the human species. To fully develop a viable alternative to the neoclassical notion of sustainability, scientific measures of the factors contributing to human well-being are needed as well as indicators of the physical and biological requirements for long-term human survival.

IX. Economists Reaction to Behavioral Economics

The reaction of most economists to behavioral economics and neuroscience has been positive. Leading economics journals regularly publish papers by behavioral economists, and leading economics departments offer courses on the subject. It must be said, however, that the rational actor model still holds sway in the economics profession. The rationality assumption lies at the core of neoclassical welfare economics and supports the major theoretical tools—equilibrium, marginal analysis, revealed preference—of economic analysis. Rank and file economists are, for the most part, unconcerned about the implications of the behavioral findings but the top neoclassical theorists recognize the threat to the core principles of Walrasian theory:

> Perhaps nothing is more readily distinctive about economics than the insistence on a unifying behavioral basis for explanations, in particular, a postulate of maximizing behavior. The need for such a theoretical basis is not controversial; to reject it is to reject economics (Silverberg 1990, 14).

There have been two major reactions by neoclassical economists to the behavioral and neuroscience challenge. They may be summarized as follows:

1. People may initially make "irrational" decisions but choosing under uncertainty is a learning process and people eventually correct their mistakes. An early version of this defense was given by Marshack and Savage (1954). A recent extension of this idea is that markets train people to be rational. John List argues that the behavior of experienced agents generally conform well to neoclassical theory. For example, professional baseball card traders do not exhibit an endowment effect, compared to amateur card traders (Levitt and List 2008, Haigh and List 2005). Their argument is that market participation helps people to learn to behave rationally and this is another justification for the expansion of markets. An empirical test among the Papua New Guinea found no evidence to support the "market integration" hypothesis (Tracer 2004).

List also found evidence that experience as a card trader spilled over when people were asked to trade other goods. Only inexperienced traders tended to be influenced by the endowment effect. A criticism of this defense is that, people are not trained in markets to make the most important decisions in their lives. Experimental economics in general has been criticized for examining behavior in unrealistic settings (the laboratory) and for training participants to make choices consistent with economic theory.

2. "Irrational" behavior might be interesting but it's not economics. This argument was made forcefully by Gul and Pensdorfer (2008) in a paper appropriately titled "The Case for Mindless Economics." They assert: "Neuroscience evidence cannot refute economic models because the latter *make no assumptions and draw no conclusions about the physiology of the brain*." In fact the validity of revealed preferences (market or pseudo market choices) as "optimal" or "efficient" depends, in the standard model, on the assumption of rational behavior. The assumptions of the standard model (transitivity, non-satiation, the independence of irrelevant alternatives, self-regarding preferences) are assertions about human psychology and ultimately about brain physiology. This is really an old debate going back to Paul Samuelson's theory of revealed preference. At first it was thought that that theory provided a "positive" foundation for economic theory, but it was soon realized that to construct indifference curves based on revealed choices required all the assumptions of *Homo economicus*.

XI. **The Importance of Evolution**

Behavioral economics is still in the process of establishing itself as a coherent alternative to the dominant Walrasian paradigm. There are several reasons for this, the main one being the infancy of behavioral economics. But another is the failure of behavioral economics to coalesce within a larger theoretical framework. Evolutionary theory may offer such a framework. Like behavioralism in general, behavioral economics ignores evolutionary history and still tends to see behavior as a collection of blank slate "anomalies." An evolutionary framework could help organize the uncovered behavioral regularities into a systematic explanation of behavior. For example, "fairness" seems to be a universal human attribute although it is manifested in different ways in different cultures. Humans have an incredible amount of behavioral and cultural flexibility but we do have an evolutionary history and genetic constraints. A good metaphor might be that the human mind is more like a coloring book than a blank slate.

Secondly, behavioral economics is still one dimensional. Behavioral economics recognizes that people may care about others but it still focuses on the decisions of individuals with no notion of groups or hierarchies. David Sloan Wilson's research shows that pro-social behavior is embedded in pro-social groups. This is a critical insight. There is a real need to explore the middle ground between bottom up policies directed at modifying individual behavior on the one hand and top-down government regulations on the other (Ostrom 1990).

Another idea from evolutionary theory is the notion of "mismatch theory." An organism may have traits that are well adapted to one environment but become maladaptive when the environment changes. For example, a craving for sugar and fat was adaptive when we lived as hunter-gatherer with scarce resources and lots of exercise but is maladaptive in today's food abundant (for most of us) and sedentary world. This also relates to hierarchy. Conspicuous consumption may be adaptive at the individual level to convey status but has become disastrous at the species level as overconsumption is undermining the planet's life support systems.

XII. Summary: Climate Change, Neuroscience and Behavioral Economics

What do we go from here? How can behavioral insights be applied to policy? What do we need to know to successfully inform climate change policy?

Most relevant findings for climate change:

1. Humans are naturally risk averse
2. Long-term planning is psychologically difficult
3. Climate change is a clear and present danger that will require significant life-style changes. Nudging is not enough. Happiness studies show that less consumption, more leisure time can make us better off.
4. Extreme malleability of individuals. But cultures are hard to change because humans are hardwired at an early age.
5. "Us" and "them" are natural categories but they can be re-defined.
6. Any policy carries the risk of unintended consequences.

XIII. Some Possible Garrison Institute Initiatives

- Develop a common research agenda that explores the following:
    - Linking neuro-economics and behavioral economics – the evolutionary basis for human behavior to climate change policy
    - Changing behavior as well as changing attitudes
    - The policy relationship between well-being, GDP, and neuro and behavioral economics
    - The role of behavior and institutions in adaptation to climate change by the world's poorest
    - The role of behavior in reducing green house gas emissions from the occupants of buildings.
    - How to enlarge the 'behavioral wedge', which amounts to 1 gigaton of reduction in CO2

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Endnotes

1. Parts of this survey are adapted from the following articles: the J. Gowdy and R. Juliá. 2010. "Global Warming Economics in the Long Run" Land Economics **86**(1), 117-130; J. van den Bergh and J. Gowdy. 2009. "A Group Selection Perspective on Economic Behavior, Institutions and Organizations" Journal of Economic Behavior and Organization **72**, 1-20; and J. Gowdy. 2008. "Behavioral Economics and Climate Change Policy" Journal of Economic Behavior and Organization **68**: 632-644.

2. Sherif himself was almost a victim of the "Us-Them" syndrome. In 1919, as a young boy he narrowly escaped being killed in the Greek massacre of Turks in the city of Smyrna in southeastern Turkey.

3. An interesting case of neoteny that might be relevant to human behavior is the difference between bonobos and chimpanzees. Compared to chimpanzees, adult bonobos are more playful and share food readily. They are also less socially inhibited as adults. A recent study (Wobber et al. 2010) suggests that this behavior is due to the retention of juvenile characteristics.