Optimizing Discount Rates: Expressing Preferences for Sustainable Outcomes in Present Value Calculations

Axelrod, David

Montclair State University

July 2017

Optimizing Discount Rates: Expressing Preferences for Sustainable Outcomes in Present Value Calculations

David Axelrod, Ph.D.,
Montclair State University

This paper describes how the discount rate used in present value calculations expresses the preference for sustainability in decision making, and its implication for sustainable economic growth. In essence, the lower the discount rate, the greater the regard for the future, and the more likely we choose behaviors that lead to long-term sustainability. The theoretical framework combines behavioral economics and holonomics, which involve limitations of regard for the future due to constraints on processing uncertainty. An alternative formulation for present value calculations, which includes a survival function, is developed. A taxonomy of institutions based on discount rate is proposed.

INTRODUCTION

The objective of this paper is to demonstrate how the discount rate used in present value calculations expresses the preference for sustainability in decision making, and its implication for sustainable economic growth. In essence, the lower the discount rate, the greater the regard for the future, and the more likely we choose behaviors that lead to long-term sustainability. The theoretical framework combines behavioral economics and holonomics. Sustainability describes a feedback mechanism between resources and behavior that is stable and enduring. Without those two characteristics, an economy (or ecosystem) would either collapse before our eyes, or at best change so dramatically that it is as if we no longer lived in the same world. The resources available underlie which behaviors are feasible. Behaviors influence what resources will be available. From an economic viewpoint, behavior is an expression of the decisions and choices we make. Behavior is understood as the outcome of preferences given the constraints/opportunities/feasible alternatives faced. However, the resources available also influence how we make decisions. This includes not only our capacity to make decisions (such as information and information technology available) but also our being as decision makers. Since sustainability has a similarity to survival processes based on allocation of resources, a preference for it can be expressed by a utility function with survival time as one of its arguments. It also shows up in the intertemporal discounting and time horizons used in cost-benefit analysis.

Some economists argue against using discount rates below market interest rates. Podenza (2011) wrote that,

"A good case can be made that market rates used to settle private financial matters already incorporate intergenerational welfare considerations through the inherent, multi-generational perspective of the human family … this justifies extending the revealed-preference approach to discounting to matters in the public realm as well."

However, the revealed-preference approach is limited by the alternatives available. It also implies that the discount rate should vary as interest rates do. This is problematic since one would have to both forecast future interest rates, as well as deal with a plan that is not self-consistent. If the time preferences of consumers influence interest rates, then the intertemporal discount rates policy makers use will also affect future interest rates. Furthermore, when individuals have greater wealth and/or working capital, their time horizons increase. Rachid Laajaj (2012) demonstrated this when studying the impact of small investments on the planning time horizons of farming households in Mozambique. Also of importance, Borrisov and Dubey (2015) suggest that entities using lower discount rates will, over time, tend to accumulate more of the economic capital of an economy. Clearly, imagining the long-term benefits of a sustainable project must capture the essence of sustainability, which means using low enough discount rates, and a long enough time horizon, to even bother to be aware of those benefits.

HOLONOMIC FRAMEWORK

While the term "holonomics" has been used for a while in mathematics and psychology, it is a relatively new term for discussing economic well-being. One conception of it is presented in the book *Holonomics* (Robinson and Robinson, 2014). Well-being is presented as an outgrowth of how we perceive the world. They suggest three major distinctions; mechanistic (objects), systems (relationships), and holonomic (meaning). The important contrast for them is that while traditional economics has profits as the goal of business activity, a holonomic approach has profits as a means to a greater good (similar to the Naïve/Sophisticated distinction discussed by Gigliotti (1988)). The framework we will use focuses on the nature of constraints and preferences. It is a recognition that our preferences over, and choices of, who we are being as decision makers deeply influence the commitments we keep, as well as what attracts our attention and shapes our priorities. These issues can be summed up in the catchphrase, "Coulda-Shoulda-Woulda."

Of Constraints and Preferences

Maybe the most foundational concept in economics is feasibility. When we say an outcome is **feasible**, it means that outcome could actually happen. It "coulda" happened if only we had chosen to make it so. Economists tend to avoid considering policies or goals that are not feasible. When one attempts to achieve something that is not feasible, there is both a failure to achieve that outcome, and depletion of the time, energy and other resources that might have been used to achieve another, more feasible, goal. Occasionally, attempting the infeasible means harm or death (like trying to fly off a mountain with no equipment or special gear). Moreover, feasibility changes over time. When someone says, "I coulda" it means she could have done it then, and cannot do so now. Feasibility is about the **exogenous constraints** we face in making choices. They are exogenous in that it is as if such a constraint was determined outside of ourselves. When people say, "get real," they are telling someone to recognize what is actually feasible.

When we say we "shoulda" done something, it means we could have benefitted from constraining our own behavior. If we had chosen differently, a better outcome might have occurred. Should is about how we focus and limit ourselves. It is about **acceptable** outcomes. These are a decision maker's **endogenous constraints**. However, it is a balancing act. Typically, the benefits from endogenous constraints show up in the future. For example, becoming proficient at a sport, or playing music, requires practice. Sometimes people must constrain what they choose to do to assure that they get the time to practice. Exercising is another example. For many people exercising is not very enjoyable, and there are many other things they would rather do. However, by consistently exercising they expand what is feasible for them to do in the future (such as staying strong and healthy longer). The distinction between feasibility and acceptability is akin to the distinction between positive and normative economics often presented in introductory economic classes.

When we say we "woulda" done something, it means we would have done it if not for the constraints we faced. I would have visited Chicago, if I'd had the money; or I would have gone hiking, if my leg hadn't been injured; or I would have gone out to the buffet, if I hadn't been fasting. These are about **external**

preferences. They are a statement about what I would have preferred to have, or do, if it had been feasible (coulda) and acceptable (shoulda). They summarize the goals, aspirations and priorities over outcomes about the world external to the decision maker. Such preferences describe what is **desirable** to the decision maker.

In contrast are **internal preferences**, which are over characteristics of the decision maker herself. They are about who we are as decision makers, and are expressed through the endogenous constraints and external preferences we use to make decisions. If external preferences drive economic choice, internal preferences drive egonomic choice. They describe what is **inspirable** within us. This is the "Wasa" extension of "Coulda-Shoulda-Woulda."

The preceding can be expressed mathematically as follows:

B = Behavior
R= Resources
F = Feasible alternative set (exogenous constraints)
A = Acceptable alternative set (endogenous constraints)
E = External preferences
I = Internal preferences

Letting U be the utility function over B given E, the decision process becomes,

$$\text{Max } U(B; E(I,R)) \quad \text{s.t.} \quad B \in F \cap A(I,R)$$

This provides us with a cute mnemonic; UBE BeFAIR. E can also be understood as a set of parameters that specify the external preferences. In the case of sustainability, we can also use the term well-being instead of utility, and we will represent that by W(B;E).

The holonomic framework we use recognizes that how we make decisions is part of the well being generated from decision making. In the case of intertemporal decision making, the sum of all weights into the future is a measure of the consideration one takes of the future. While the discount rate quantifies the external preference over future events, it also expresses something about who we are as decision makers. For some, sustainability is a moral issue, and is part of their endogenous constraints, of what they must do (e.g. "I always recycle"). For others, it is an ethical issue and derives from their internal preferences to be concerned, in a pragmatic way. Since sustainable outcomes require future decision makers to continue to choose with similar regard for the future (an issue of self-consistency in planning), part of setting the discount rate is based on whether resource usage and behavior maintain the long view. A robust plan would incorporate enough resources to sustain the psychological and spiritual requirements of decision makers to keep that view.

This framework allows us to consider economic activity as an outgrowth of the spirit (preferences), religion (establishment of endogenous constraints) and science (study of exogenous constraints) of the people of an economy, as well as their resources available. One could also relate this to the law: the spirit of the law, the letter of the law, and the long arm of the law. When seen in the light of the above, what we do in the economy, and even how we understand economics, is entangled with the scientific, the religious, and the spiritual. Economies do not just produce goods and services while making money. Economies produce people and ecologies that experience life, including spiritual expression, religious meaning, and scientific curiosity (read more on this in the appendix).

DISCOUNTING, TIME HORIZON AND PREFERENCE FOR SUSTAINABILITY

The discount rate and time horizon used in present value calculations are expressions of the preference for sustainability. Lower discount rates and longer time horizons can increase the calculated benefit from enduring farther into the future. As such, the propensity for sustainable outcomes is dependent on parameters that are set by the policymaker. Businesses, including corporations, as economic actors, also

have preferences. Typically they are "for-profit", and tend to use measures of profit as the utility function that quantifies their preferences. How expected profits are estimated is, in essence, the spirit of a for-profit corporation. The endogenous constraint that expected profits should be positive is, in essence, the morality of a for-profit corporation. This is in contrast with "for-survival" entities (like most humans) where retirement still has value, even if it decreases net worth. When faced with the question of sustainability, a traditional "for-profit" only considers duration to the extent that it increases that measure of profit. Likewise, sustainability tends to be conceived as a characteristic of the products they sell, or how they market their brand, rather than a priority to be expressed. Non-profits, not-for-profits and governmental agencies are more likely to consider the duration of an ecosystem, socioeconomic system or nation as part of their objectives, and not just a strategy or tactic.

To clarify the importance of the discount rate to implementing sustainable solutions, consider how economists model intertermporal decision making. The simplest version (Fisher, 1930) involves a two-period model, using a utility function of the form

$$U(C_0, C_1) = U(C_0) + wU(C_1) \quad (1)$$

where C_0 = consumption now, C_1 = consumption in the future, and w = the weight of future utility. Typically, it is assumed that w is between 0 and 1 to indicate that future consumption is considered, although not as important as consumption now. The solution suggests, w = (1/1+r) where r is the interest rate. More sophisticated models will have multiple discrete periods, or continuous time, using a different weight for each moment. Typically, such intertemporal models will assume a declining series of weights, to indicate the farther out into the future, the less of consideration by the decision maker. The sum of all these weights is a measure of the consideration of future consequences. To avoid confusion with the term used as a personality trait by Stratham et al. (1994), and for succinctness of exposition, we will use the term **regard** for the sum of these weights. In essence, one characteristic of the internal preference for sustainability is to have the greatest regard for the future, given the resources available to express regard. Mathematically, the definition will be

$$\text{Reg}(T) = \sum_{t=1}^{T} w_t \quad \text{if discrete periods, or} \quad \int_0^T w_t \, dt \quad \text{if continuous time} \quad (2)$$

where w_t is the weight at time t, and T is the time horizon (the distance into the future considered). Note that in the two period model, regard would equal w and be less than 1. In the multi-period model, the sum of the weights can be more than 1.

In present value calculations, and many economic models, these weights are assumed to decline exponentially with a discount rate ρ. It provides a self-consistency described by Strotz (1956). Mathematically, we shall define this as

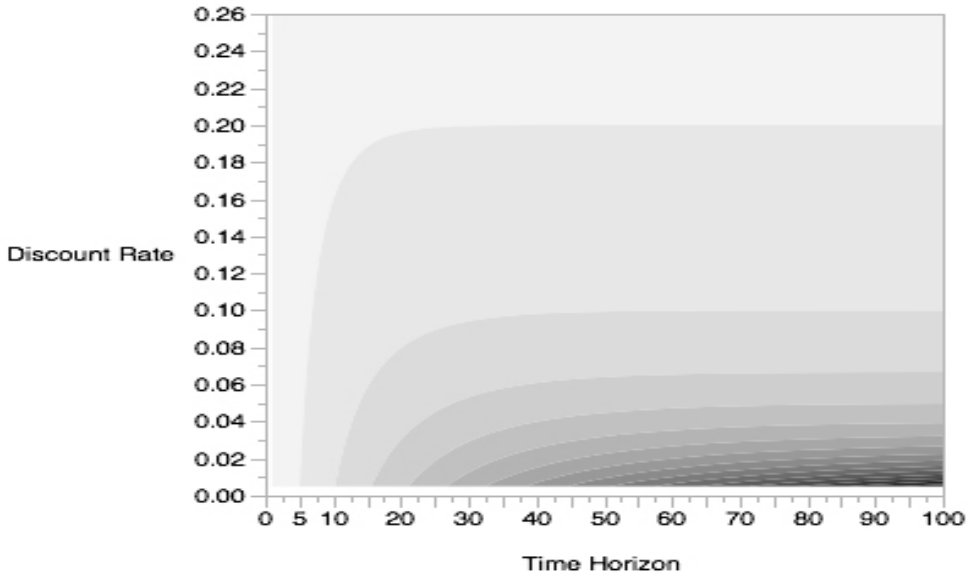
$$\text{Reg}(\rho, T) = \sum_{t=1}^{T} \exp(-\rho t) \quad \text{if discrete periods, or} \quad \int_0^T \exp(-\rho t)\, dt \quad \text{if continuous time} \quad (3)$$

Thus, the greater the regard for the future, the more influential future outcomes are in decisions made today.

Because of its similarities to decay rates, one can also associate the discount rate with the half-life of weighting the future. This is the point where half of regard occurs before, and half after. Estimates of personal discount rates, such as Hausman (1979), suggest a rate of about 25%. That is a half-life of three years. Using the 10% discount rate mandated in 1981 by U.S. presidential executive order 12291 for cost-benefit analysis back in the early 1980's gives a half-life of seven years (about the length of a two-term presidency). Using the 2.5% rate of a recent mix of treasury bonds, gives a half-life of 28 years. It would require a discount rate of no more than 0.5% to express the intertemporal preferences of the "seventh generation" principle described by Lyons (1980), assuming a generation is about twenty years. Even if the technology were immediately available, without the decision maker having a high regard for the future, the investments will not be made or maintained. Only at very low discount rates would substantial regard

toward intergenerational sustainability (i.e. 50 years or more) be expressed. This is graphically presented in Figure 1. The lightest shade represents a regard ≤ 5. Shades darken at intervals of 5.

FIGURE 1
REGARD, BY TIME HORIZON AND DISCOUNT RATE



BEHAVIORAL FRAMEWORK

The behavioral economic component of the paper concerns the finite capacity of decision makers to process uncertainty. Here it is formalized as a "certainty principle." This is represented mathematically as either:

$$\sum w_t * \sigma_t \leq \sigma_c \qquad \text{or} \qquad \int w_t * \sigma_t * dt \leq \sigma_c \tag{4}$$

where w_t is the weight in decision making of an event at time t, σ_t is the uncertainty of an event at time t, and σ_c is the capacity of the decision maker to process all uncertainty. In essence, uncertainty is a cost of considering an event. It also suggests an important distinction between emotional and rational decision making. Emotional decision making requires feelings as the processing medium, where w would represent the strength of feeling, and σ_c the available emotional resources to process it. Rational decision making is not constrained by the capacity to feel, but by the capacity to analyze. This shows up as the quantity and quality of data, uncertainty to the facts of the matter, and information technology. While the focus of this paper is setting discount rates and time horizons for cost-benefit analysis, the full human cost to choose and implement sustainable policies should not be ignored.

Assuming self-consistency, the weights will exponentially decline with time and are associated with a discount rate (Strotz, 1956). However, such perfect self-consistency would be limited by (4). It has been shown that under such constraints, the weights will decline until a point in time after which the weights fall to zero and stay at zero thereafter (Axelrod, 1990). This leaves us with a special case for the continuous time model:

$$\int_0^T e^{-\rho t} * \sigma_t * dt \leq \sigma_c \tag{5}$$

where T is the time horizon, after which the weights fall to zero. In essence, the decision maker eliminates more uncertainty by ignoring outcomes beyond the time horizon. Given an evolution of uncertainty (path of σ_t), it provides an interesting tradeoff. As the discount rate is lowered, so is the maximum T available.

The implication is that to induce lower discounting **and** extended time horizon, one must either decrease uncertainty through time, or increase the capacity to process uncertainty. Viewed in another way, given finite decision making resources, we either reduce our focus on the future, or we must censor the distant future out of consideration altogether.

The next step is to express the nature of uncertainty through time. A simple first approach is to assume uncertainty to grow exponentially through time. This is similar to the propagation of waves. It also captures the notion that the farther we attempt to look into the future, the foggier it becomes. Letting σ_0 be the uncertainty at t=0, we have the following:

$$\sigma_t = \sigma_0 * e^{\nu t} \tag{6}$$

Substituting into (5):

$$\int_0^T e^{-\rho t} * \sigma_0 * e^{\nu t} * dt \leq \sigma_c \tag{7}$$

$$\int_0^T e^{(\nu-\rho)t} * dt \leq \sigma_c / \sigma_0 = N \tag{8}$$

where N = capacity of uncertainty in units of uncertainty at time 0. Continuing with the derivation,

$$\frac{1}{(\nu-\rho)}(e^{(\nu-\rho)T} - 1) \leq N \tag{9}$$

Internal preferences for sustainability suggest maximizing regard given decision making resources N. In the special case of an infinite time horizon, this implies using the minimum possible ρ that satisfies

$$\frac{-1}{(\nu-\rho)} \leq N \rightarrow \rho \geq \nu + \frac{1}{N} \tag{10}$$

So, the minimum possible ρ is ν + 1/N.

Let us now consider optimizing T if we specify ρ above this minimum. Solving (9) for T gives us,

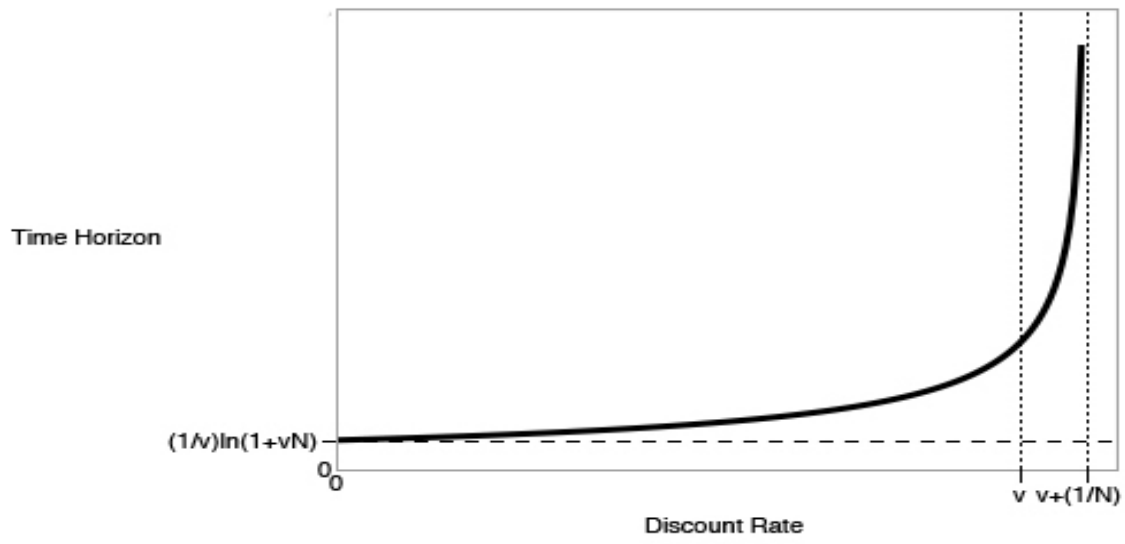
$$T \leq \frac{1}{(\nu-\rho)}\ln(1 + (\nu-\rho) * N), \quad if\ \nu > \rho$$

$$T \leq N, \quad if\ \nu = \rho \tag{11}$$

$$T \leq \frac{1}{(\nu-\rho)}\ln(1 + (\nu-\rho) * N), \quad if\ \nu + \frac{1}{N} > \rho > \nu$$

This means that present value calculations that assume an infinite time horizon (for tractability), would use a discount rate of ν + 1/N. In the other direction, when ρ = 0, the optimal T is $(1/\nu)*\ln(1 + \nu N)$. This is displayed in Figure 2, where the areas below, and on, the solid line are attainable combinations of T and ρ given N. While the above is an oversimplified model of the nature of bounded rationality in decision making, it does capture some important insights. First, there is a distinct tradeoff between how much we can weight the future in our plans, and how far into the future we are planning. Second, there is a tradeoff between using resources for making decisions, and using them for implementing them. We can increase our regard for the future, but it might be at the cost of fewer resources to express that regard.

FIGURE 2
T-ρ FRONTIER UNDER FINITE DECISION MAKING



The Myopic Trap

Since the uncertainty over the future is influenced by the choices made by those living in the present, there is a recursion. This leads to a potential "myopic trap," a vicious cycle of increasing shortsightedness. In this situation an event occurs (either natural or anthropogenic) which decreases expectations or increases uncertainty about future well-being, leading to increased weighting toward the near term, and thus decreased investments toward the sustainability into the far term. This change reinforces behavior that makes the future less desirable to consider, thereby reinforcing an even more myopic view. For example, how we weight the future influences whether a clean water system is built. Whether that system is built influences how long a community will survive. The expectations of survival influence the uncertainty of the community's future. The greater the uncertainty, the less the future is weighted, and the more myopic the decision making. This can be derived from the model above by noticing that if ν increases then either ρ increases, T decreases or both. Avoiding this trap requires valuing, even inspiring, the long-term view. This could necessitate investing resources to increase regard for the future.

VALUING SUSTAINABILITY

One way to account for a preference for sustainability is to include a constant, which is not discounted, to each moment in the present value calculation. It is the value of survival, distinct from the net economic benefit. Another way is to further discount the net benefit by the survival probability of the system. One example would be a well-being function of the form:

$$W = \int(\alpha + \pi_t e^{-\rho t}) S_t dt \tag{12}$$

$$= \int \alpha S_t dt + \int \pi_t e^{-\rho t} S_t dt \tag{13}$$

$$= \alpha ET + PV(S\pi; \rho) \tag{14}$$

where α is the existential value of the system, π_t is the net economic benefit at time t, and S_t probability of the system surviving through at least t. ET is the expected survival time of the system, $S\pi$ is the stream of expected net benefit discounted by survival rates and PV is the present value of $S\pi$ given discount rate ρ.

In other words, well-being is the weighted sum of expected duration plus the survival-weighted economic present value. Setting the value for α is inherently subjective. One possibility is to use population. However, even if policy makers were to use some version of GDP or other measure of economic activity for α, this approach still includes a preference for sustainability in a more substantial way.

We continue our example by assuming a current lump sum investment Inv that generates a constant net benefit $\pi(\text{Inv})$. This is similar to buying a perpetual bond. This means that $\pi_0 = -\text{Inv}$, and $\pi_t = \pi(\text{Inv})$ for all $t > 0$. If the survival function is a simple exponential with hazard rate λ, also dependent on Inv, we derive the following:

$$W(\text{Inv};\ \alpha, \lambda, \rho) = \int \alpha e^{-\lambda(\text{Inv})t} dt + \int \pi(\text{Inv}) e^{-\rho t} e^{-\lambda(\text{Inv})t}\, dt - \text{Inv} \tag{15}$$

$$= \frac{\alpha}{\lambda(\text{Inv})} + \frac{\pi(\text{Inv})}{\rho + \lambda(\text{Inv})} - \text{Inv} \tag{16}$$

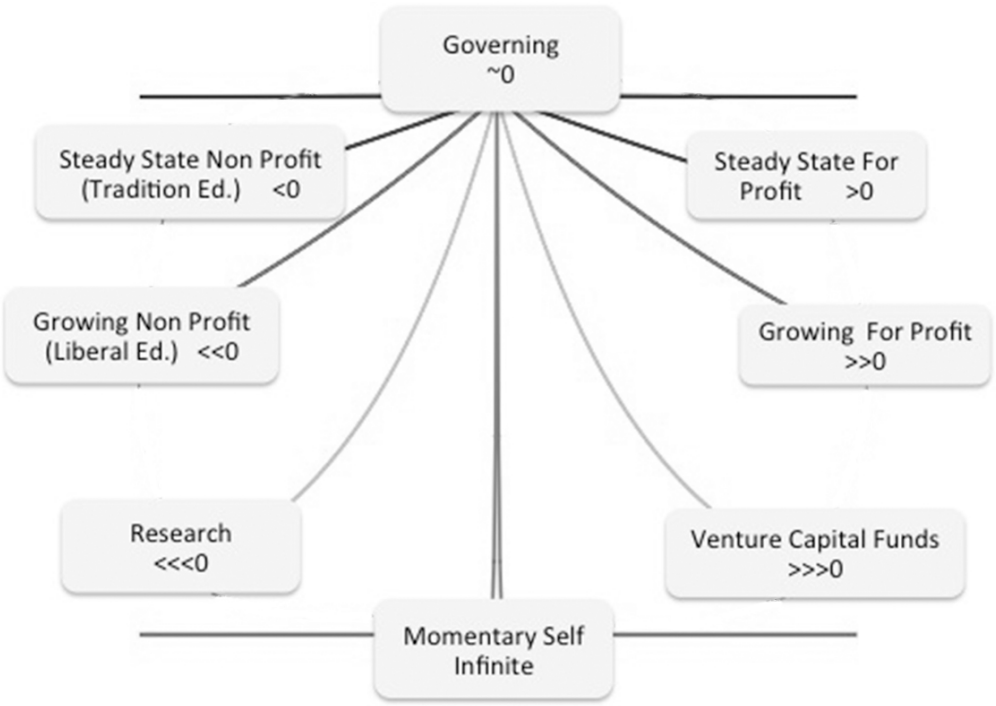
Note that the lower λ is, the higher probability of survival, and thus the greater expected duration. Again, this is a very simplified model, but it does capture a preference for sustainability through adding value for duration, and for reducing present value of economic benefit if it negatively affects the probability of survival.

As noted before, in the case of finite regard for the future, an infinite time horizon is associated with $\rho = \nu + 1/N$. What happens if the investment is not toward infrastructure or other tangible elements of the system, but rather toward regard for the future? In this case, N would be considered an increasing function of Inv, and we get $\rho(\text{Inv}) = \nu + 1/(N(\text{Inv}))$. If regard increases with investment, then the discount rate falls as the investment in regard increases. Whether this increases well-being depends on how much transforming our economy to choose from deeper sustainable principles displaces resources for survival and economic benefit. In less technical terms, in a world with scarce resources, sustainability requires a balancing act of spiritual sustenance and material production.

SUSTAINABILITY AND INSTITUTIONAL ECOLOGY

Another way to understand optimizing discount rates is to consider the distribution of discount rates used by various institutions. It is a taxonomy based on the discount rate ρ. For example, research on venture capital funds (Fuerst and Geiger, 2003) indicates discount rates in the 20-80% range. In contrast, the Inter-American Development Bank (2016) uses a real discount rate of 12%, sometimes lower for very long-term projects. These discount rates account for both the rate of return and risks involved, from a profit-making perspective. On the other hand, institutions with sustainability missions have an inverted, although complementary, relationship with for-profits. Whereas the financial benefit in the future is equivalent to less today, due to interest income (if positive!), the benefit of sustainability increases with time. This occurs for a couple of reasons. First, as population increases more people benefit in the future. It is reasonable to argue that discount rates be lowered by the population growth rate. Second, whereas for-profits are seeking to maximize profits per unit of time (for example a calendar quarter), sustainability is oriented to maximizing the amount of time for a given resource. It is as if the accumulation of memories makes the future even more valuable. Negative discount rates capture the enduring benefits of endeavors like education and research. With this in mind, Figure 3 suggests how the spectrum of institution types would fit on a continuum of discount rates. The horizontal line indicates weighting when the discount rate is zero. Downward sloping curves indicate a positive discount rate. Upward sloping curves indicate a negative discount rate. A vertical line indicates an infinite discounting (whether positive or negative), which implies regard only for the immediate moment.

FIGURE 3
CONJECTURED SPECTRUM OF INSTITUTIONAL TYPES BY DISCOUNT RATE



From this perspective, another way to change the discount rate for the economy as a whole is to change the distribution of resources. If resources are distributed away from institutions with very high discount rates and toward those with low discount rates, then those resources are more likely to express the preference for sustainability. There are several approaches to consider. As Borrisov and Dubey (2015) have written about, free markets with liquid capital assets would naturally tend toward capital accumulation by entities with lower discount rates. What limit this approach are the frictions of actual markets, as well as their tendency toward capital monopolization (although it is these frictions which would limit this). A second approach is socialist/revolutionary where resources are forcibly redistributed. The obvious limitations here would be large transition costs, and social disruption, which could easily negate the potential benefits. Another approach would be to view the discount rate spectrum similarly to the radio spectrum. There, radio and TV stations license bandwidth to channel their communications. In a way, if money is speech, then the discount rate is the frequency on which it transmits. Institutions could then bid on the discount rate they will use for present value calculations in decision making. Subsidies could be provided for unused, or underused, discount rates. In a variant to this, one could imagine that entities identify and compete for market share on the basis of the declared discount rates, or regard, they use. While these last suggestions may seem wildly speculative, it is the intent of this paper to offer new approaches to consider how to express our preferences for sustainability, and to begin to address the distinction between buying the sustainable brand, and choosing from a sustainable spirit.

CONCLUSION

How we rationalize discount rates in economic decision making says much about our priorities and limitations. From a behavioral perspective, it is the constraints over how much we can consider the future that limit our time horizons and discount rates. From a holonomic perspective, our internal preferences are the inspiration to value sustainable outcomes. Managerial and policy implications include investing resources to maintain the regard for the future, while still incorporating profit/utility maximization as a

tactic for behavioral determination, with appropriate endogenous constraints. This suggests that the most immediate and significant action to support sustainable outcomes is to lower the discount rate and/or increase time horizons used by governmental and large corporations, thereby increasing the value of the future as a resource. In essence, as long as the future is full of positive income, decreasing the discount rate has a positive wealth effect. This is also consistent with increasing long-term investments, and stimulating economic growth, and provides a counter-balance to the uncertainty the global economy faces. Beyond this, including a value for our economic and ecological systems existing (and not just the stream of profits), and accounting for survivability, will more accurately capture the benefits from increasing sustainability.

REFERENCES

Ainsle, G. (1986). Beyond Microeconomics: Conflict Among Interests in a Multiple Self as a Determinant of Value. *The Multiple Self*, ed. J. Elster, Cambridge University Press, Cambridge, 133 – 175.

Axelrod, D. (1990). The Rationality of Positive Time Preference. *Three Essays on Latency in Economics and Decision Making*, Doctoral Dissertation.

Becker, G. (1976). *The Economic Approach to Human Behavior*, University of Chicago Press, Chicago.

Bohm-Bawerk, E. von (1959). *Capital and Interest Vol.II*, Libertarian Press, South Holland.

Borrisov, K. and Dubey, R. (2015). A Characterization of Ramsey Equilibrium in a Model with Limited Borrowing. *Journal of Mathematical Economics*, 56 (2015), 67-78.

Feldstein, M. (1974). The Social Time Preference Rate. *Cost-Benefit Analysis: Selected Readings*, ed. Layard, R., Penguin Books, Baltimore.

Fishburn, P. and Rubinstein, A. (1982). Time Preference. *International Economic Review*, 23(3), 677 -694

Fisher, I. (1930). *The Theory of Interest*, The Macmillan Company, New York.

Frank, R. (1987). If Homo Economicus Could Choose His Own Utility Function, Would He Want One with a Conscience?. *American Economic Review*, 77(4), 593 – 604.

Fuerst, O. and Geiger, U. (2003). *From Concept to Wall Street: A Complete Guide to Entrepreneurship and Venture Capital.* Financial Times Prentice Hall, Upper Saddle River, NJ.

Gigliotti, G. A. (1988). The Conflict between Naive and Sophisticated Choice as a Form of the Liberal Paradox. *Theory and Decision*, 24(1), 35 – 42.

Goldman, S. (1980). Consistent Plans, *Review of Economic Studies*, 47, 533 – 537.

Hammond, P. J. (1976). Endogenous Tastes and Stable Long-Run Choice. *Journal of Economic Theory*, 13, 329 – 340.

Inter-American Development Bank. *Economic Analysis Overview - Assumptions and Methodologies.* Retrieved September 10, 2016, from http://www.iadb.org/en/topics/developmenteffectiveness/ evaluation-hub/economic-analysis- overview-assumptions-and-methodologies,17882.html

Laajaj, R. (2012). Closing the eyes on a gloomy future: Psychological causes and economic consequences. Pacific Development Economics Conference, University of California, Davis.

Markowitz, H. (1959). *Portfolio Selection*. John Wiley & Sons, Inc., New York.

Miller, R. (1981). *Survival Analysis*. John Wiley & Sons, Inc., New York.

Lyons, Oren (1980). An Iroquois Perspective. *American Indian Environments: Ecological Issues in Native American History.* Vecsey C, Venables RW (Editors). New York: Syracuse University Press, 173-174.

Podenza, R. (2011). Sustainability and the Discount Rate: An Economist's Perspective. https://osbsustainablefuture.org/the-long-view-archives/home/section-newsletter/20114winter1pozdena

Robinson, S. and Robinson, M. (2014). *Holonomics*, Floris Books, Edinburgh.

Strathman, A., Gleicher, F., Boninger, D. S., & Edwards, C. S. (1994). The consideration of future consequences: Weighing immediate and distant outcomes of behavior. *Journal of Personality and Social Psychology*, 66(4), 742-752.

Strotz, R. H. (1955–56). Myopia and Inconsistency in Dynamic Utility Maximization. *Review of Economic Studies* 23(3): 165–180.

APPENDIX

Science, Religion, and Spirit

Science is the study of the observable universe. Physics, chemistry, biology, and other scientific disciplines, all have in common the accumulation of observations ("data") as the basis for understanding how the world works. Theories are developed to explain how these observations fit together. However, theories are also expected to make predictions about what will happen. If new data is collected that contradicts these predictions, the theory is considered flawed, and work on a new theory begins. It is a never-ending process. As such, what makes scientific work practical is how it improves technology. Technologies, like wireless devices and computers, are what allow humans to build and produce as much as we do. Science is the basis for expanding our knowledge of what we can, and cannot, do. That which is scientific focuses on how we are constrained by the world around us.

In contrast, the religious focuses on constraining ourselves. The word religion comes from the Latin root that means, "to tie back." Religion is the basis for knowing what we should, and should not, do. This can have substantial long term-benefits, as well as costs. Common among almost all religions is a calendar of important events. Nature religions tend to focus on change of seasons, and were essential for knowing when to plant, harvest, feast and prepare for the depths of winter. Whatever the deities worshipped and legends honored, it would have been a tremendous advantage to adhere to the behavioral cycles of the year. Other moral aspects, such as prohibitions against murder and theft, would have made it easier and more sustainable for people to live together in large communities. This expanded what they could do together, whether in dealing with the exigencies of the natural world, or in competition with other communities. On the flip side, such moral imperatives were often associated with punishment and ostracism. If these were too stringent, or the punishment too severe, it could actually decrease the coherence of society, as well as generating unnecessary suffering. Moral superiority could mean having a better set of values (how one constrained oneself), or could mean having a greater authority to impose those values (how one constrained other people).

Spirit, as the animus with which we choose to behave, is the core of what we would, or would not, do. A kind spirit tends to express kindness in their actions, limited only by what is feasible. An "evil" spirit tends to harm, and cause pain, upon others, when they are unconstrained. A strong spirit has very distinct and compelling preferences. Indeed, much spiritual work requires one to imagine what one would do if one could do anything. This is very similar to discovering what your preferences are when you have no constraints. Part of a spiritual path is becoming clear about what your preferences are, and how you constrain yourself. The deepest spiritual work involves personal and universal identity, where the distinction between internal and external is questioned. The implications can be profound.