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TIME PREFERENCE AND THE PERSONAL VALUATION OF FINANCIAL INVESTMENTS

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ABSTRACT

We use temporal value charts to illustrate the influence of time preference upon the personal valuation of financial investments. In a series of thought investments, an invested $1 is projected forward and the projected value is discounted back, both exponentially and hyperbolically. These thought investments feature three expressions of time preference: temporal neutrality (in which discount rates equal projection rates); positive time preference (discount rates exceed projection rates); and negative time preference (discount rates less than projection rates). We suggest reasons why projection and discount rates might differ. We consider how to test experimentally for time preference using this framework.

Keywords: time preference; discount rates; personal valuation; behavioural economics

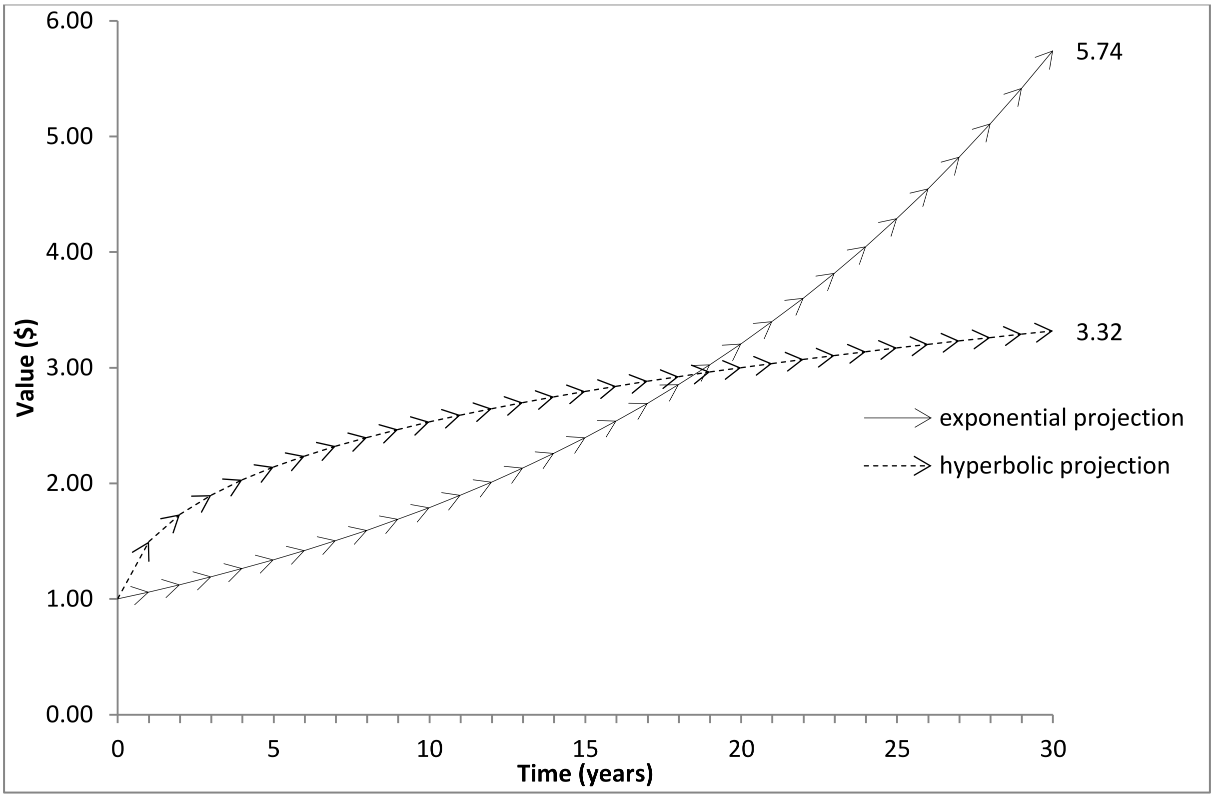
JEL: G02

1. **INTRODUCTION**

This paper was motivated by a discussion at a conference that one of the authors attended some years ago about whether \$1 invested in bonds is worth more than, less than or the same as \$1 invested in equities. Valuing financial investments, such as bonds and equities, involves mental time travel – forwards and backwards. In the paper, we explore some of the different valuation paths such mental time travel might take. We do so through a series of "thought investments" in which: an invested \$1 is projected forward; and the projected value is discounted back to the present.[1]

Projections are integral to financial investment valuation. Indeed, all financial decisions can be viewed as being based on forecasts of future value (Utkus, 2011). Chart 1 illustrates two projection methods. An invested \$1 is projected forward 30 years: "exponentially" to \$5.74[2] and "hyperbolically" to \$3.32.[3]

CHART 1: EXPONENTIAL AND HYPERBOLIC PROJECTIONS



Source: Mitchell and Utkus (2004)

Exponential projection is a standard assumption in time value of money calculations with rates being postulated not to vary today, tomorrow or, indeed, many years from now. Exponential investors foresee future values increasing at a constant rate, thanks to the benefits of compounding. Not all investors project exponentially, however. Hyperbolic investors, by contrast, expect \$1 invested to

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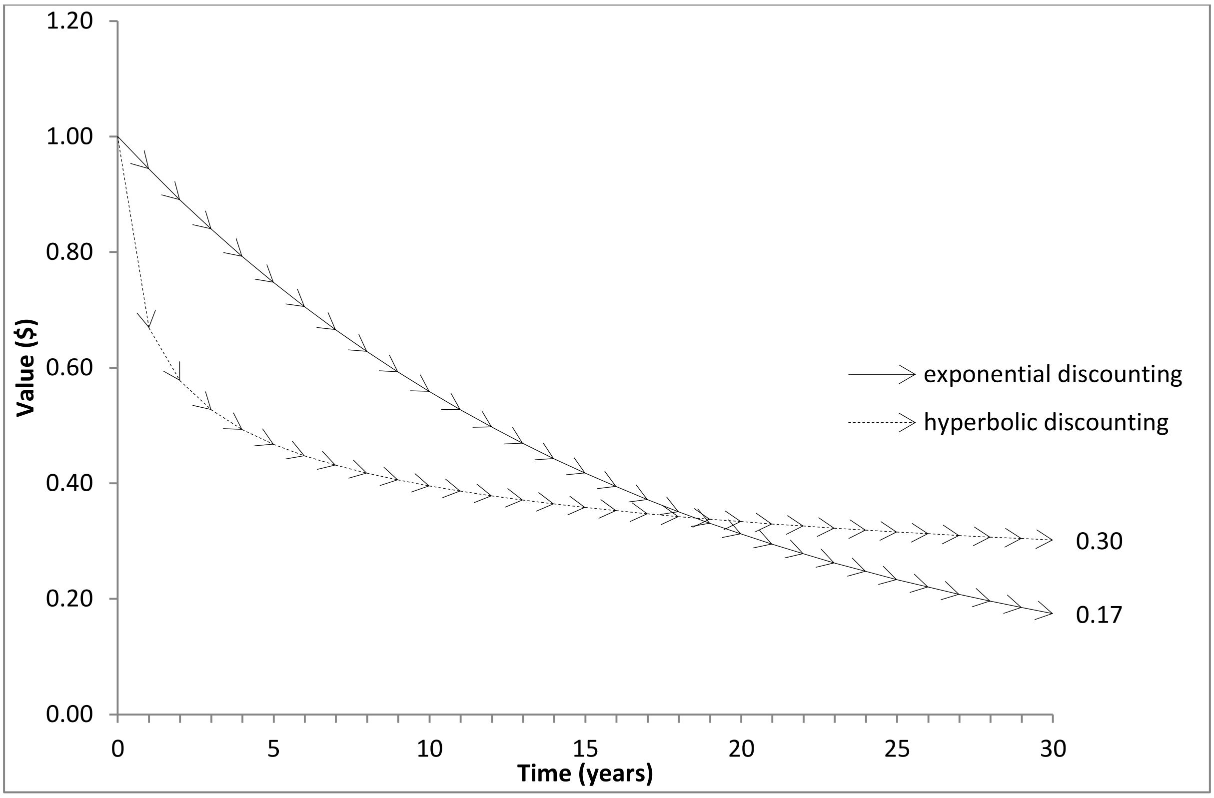
[1] Where "thought investment" is used in the same sense as is "thought experiment".
[2] We use the formula $(1+r)^T$ to define the exponential projection function for a T-year investment horizon. Chart 1 assumes that r = 6%.
[3] We use the formula $(1+\alpha T)^{\gamma/\alpha}$, where γ and α are constants, to define the T-year hyperbolic projection function (Loewenstein and Prelec, 1992, Laibson, 1998). Chart 1 assumes γ = 1 and α = 4.

grow more rapidly in the short-term than in the long-term. So, they perceive decreasing benefits to long-term investment – rewards are expected to accelerate quickly and then taper off (Mitchell and Utkus, 2004). The hyperbolic projection curve in Chart 1 reflects this: it rises more rapidly in the near future (the first five years) than in the far future (the last five years).

Chart 1 records the projected value of a thought-invested $1 over a 30-year investment horizon. Chart 2 illustrates the discounted value of $1 as a result of its payment being deferred. The $1 is discounted over 30 years: exponentially to $0.17[4] and hyperbolically to $0.30.[5] Practitioners typically assume that discount functions are exponential (Angeletos et al., 2001), whereas a growing body of experimental evidence suggests that hyperbolic discounting – in which value declines at a more rapid rate in the short-term than the long-term – better describes how many individuals value delayed rewards (Thaler, 1981, Frederick et al., 2002, Laibson, 2003, Ainslie, 2005 and Berns et al., 2007).[6] The hyperbolic discount curve in Chart 2 reflects this: it falls more rapidly in the near future (the first five years) than in the far future (the last five years).

CHART 2: EXPONENTIAL AND HYPERBOLIC DISCOUNTING



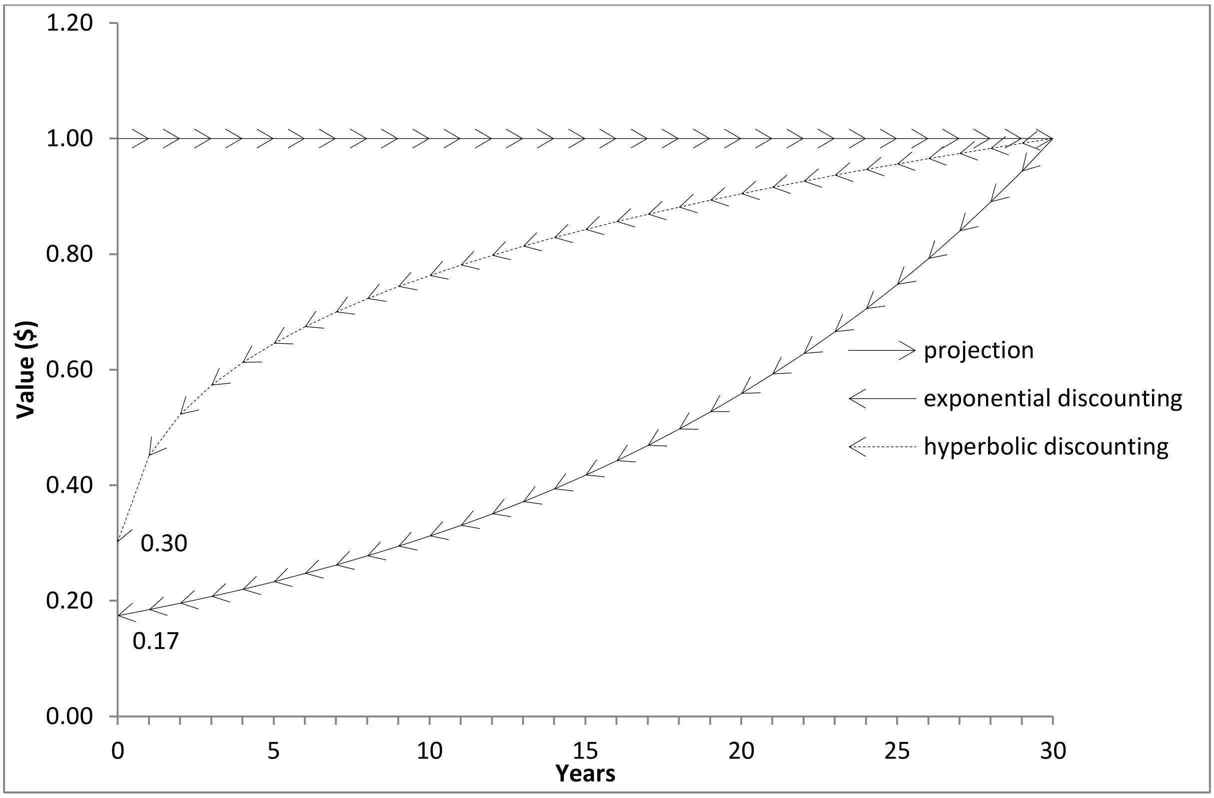
Source: Angeletos et al. (2001), as amended.

Chart 3 is an alternative way of illustrating the effects of deferring a $1 payment. The $1 is projected forwards 30 years (at a zero rate) and then discounted back to the present at the same annual rates

[4] We use the formula $(1+R)^{-T}$ to define the T-year exponential discount function. Chart 2 assumes that R=6%.
[5] We use the formula $(1+\alpha T)^{-\gamma/\alpha}$ to define the T-year hyperbolic discount function (Loewenstein and Prelec, 1992, Laibson, 1998). Chart 2 assumes that $\gamma = 1$ and $\alpha = 4$.
[6] Exponential and hyperbolic discounting are the two methods that feature most prominently in the time preference research literature, but there are, of course, others: Doyle (2013), for example, identifies over twenty methods.

as in Chart 2. The exponential discount curve falls at a constant rate, whereas the hyperbolic discount curve falls more rapidly in the near future (years 1 to 5) than in the far future (years 26 to 30), as in Chart 2. The deferred $1 has a value of $0.17 when discounted exponentially and $0.30 when discounted hyperbolically.[7]

CHART 3: ZERO RATE PROJECTION WITH EXPONENTIAL AND HYPERBOLIC DISCOUNTING



Frederick et al. (2002) and Hayden (2015) distinguish “time discounting” – the devaluation of future rewards for any reason (including uncertainty, changing tastes and a future $1 being worth less than a current $1 when interest rates are positive, etc.) – from “time preference” – discounting driven solely by a preference for the timing of rewards.[8]

The thought investments that now follow adopt the projection-discounting framework featured in Chart 3. They project forward a thought-invested $1, as in Chart 1, and then discount back the projected value to a “personal value”. They illustrate the effects of three expressions of personal time preference: “positive” – a preference for rewards sooner rather than later; “negative” – a preference for rewards later rather than sooner; and “neutral” – no preference as to the timing of

[7] The discount curves in Chart 2 record the current value of $1 as a result of its payment being deferred. The discount curves in Chart 3 record all of those projected values which have a current value of: $0.17 when exponentially discounted at a constant rate of 6% per annum; and $0.30 when hyperbolically discounted at the appropriate annual discount rates. The annual discount rates with hyperbolic discounting can be inferred from the one-year hyperbolic discount functions, $[(1+\alpha t)/(1+\alpha(t-1))]^{-\gamma/\alpha}$, $t = 1,T$, and $(1+\alpha t)^{-\gamma/\alpha} = 1$ when $t = 0$. (The hyperbolic discount functions between years s and t are given by $[(1+\alpha t)/(1+\alpha s)]^{-\gamma/\alpha}$, with $s = 0$, $t - 1$ and $t = 1,T$.)

[8] Distinguishing time discounting from time preference is not straightforward, given that one of the reasons for discounting is time preference and that the reasons for time preference might also be reasons for discounting.

rewards. Personal time preference is revealed in differences between discount and projection rates: a discount rate greater than the projection rate characterises positive personal time preference; a discount rate less than the projection rate reflects negative personal time preference; and no difference in rates signifies personal temporal neutrality.[9]

In these thought investments, the initial $1 is thought invested at current market value. It is implicit that: market value is itself a discounted projected value; the market discount rate incorporates market time preference; market time preference is an aggregation of the individual personal time preferences of all market participants weighted by the size of their transactions; and the market discount rate equals the market projection rate. Positive personal time preference implies, therefore, a discount rate greater than that of the market whereas negative personal time preference implies a discount rate less than that of the market. Finally, differences between personal and market time preferences are in no way intended to imply that market values reflect pricing anomalies or give rise to arbitrage opportunities.

As with Charts 1 and 2, the specific numbers used in this paper are arbitrary and are chosen purely for illustrative purposes – it is not any specific projection rate or discount rate that matters but, rather, the differences between rates. Accordingly, we hold the projection curve fixed, for the most part, and allow the discount curve to vary.[10] To keep things simple, we assume a positive expected return – in the form of capital appreciation rather than income – on all thought investments.

2. **TEMPORAL NEUTRALITY**

Temporal neutrality is the absence of past, present or future time preference. Temporal neutrality assigns no normative significance per se to the temporal location of benefits and harms within a person's life and demands equal concern for all parts of that life (Brink, 2011). Brink traces the concept back to the Epicureans who believed in a symmetry between our pre-natal and post-mortem non-existence – the past time before our birth being a mirror-image of the time to come after our death (Lucretius, cited by Brink, 2011).[11]

Temporal neutrality is reflected in a discount rate that equals the projection rate over the valuation period. So, in this case, personal value equals market value. Chart 4 illustrates this by bringing together the growth and discount curves in Charts 1 and 3, respectively. As in Chart 1, an invested $1 is projected forward 30 years exponentially to $5.74 and hyperbolically to $3.32. Those projected values are each then discounted back, at annual discount rates identical to their annual projection rates, to $1 today: $5.74 is exponentially discounted; and $3.32 is hyperbolically discounted. In both cases, $1 thought invested today has a personal value today of $1.

[9] The proposal that no difference in projection and discount rates signifies personal temporal neutrality is consistent with the insight that, if we can borrow or lend at rate *r*, we should be equally pleased with $1 now and $(1+*r*) in a year's time, since we can always exchange the one for the other (Ramsey, 1928).
[10] Fixed exponential and hyperbolic projection curves are apposite given that recent research reveals mental time travel to the future to be more prototypical, or common, than that back to the past (Kane et al., 2012).
[11] This "symmetry argument" presumes non-existence both before and after life.

CHART 4: TEMPORALLY NEUTRAL EXPONENTIAL AND HYPERBOLIC VALUATION

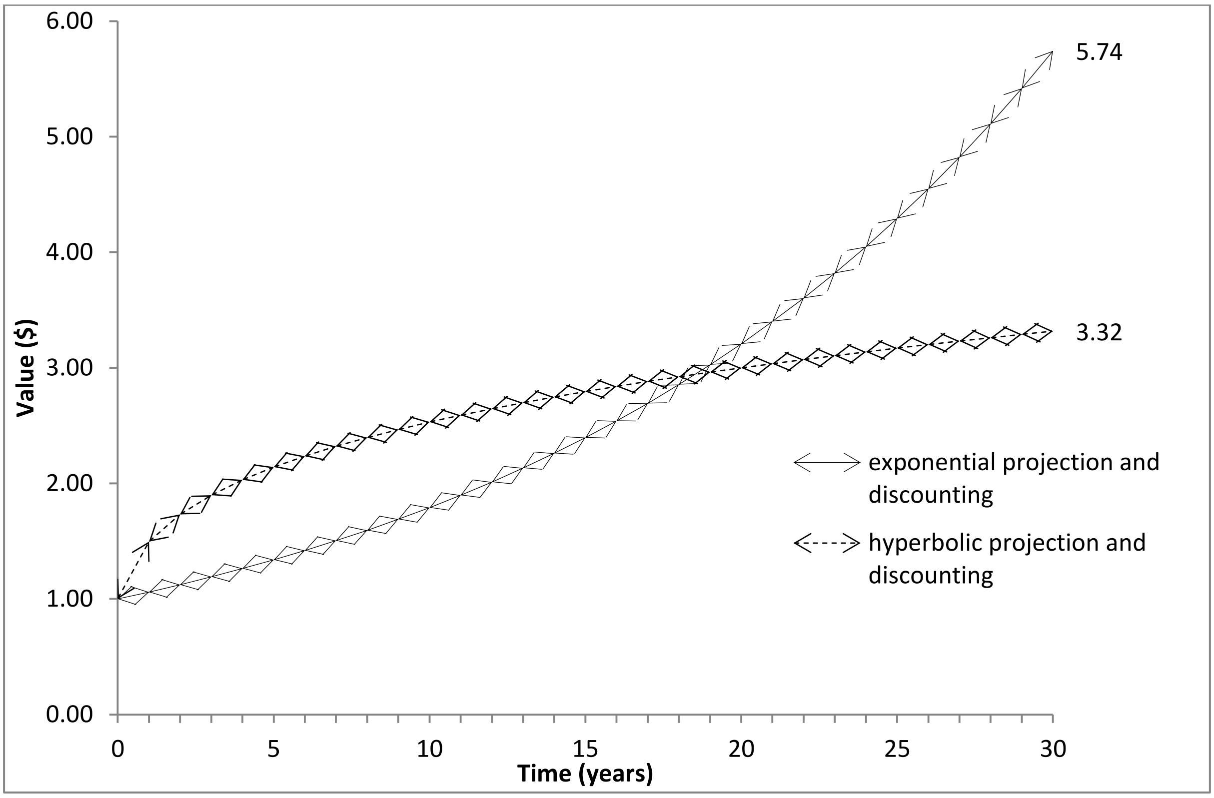


CHART 5: TEMPORALLY NEUTRAL EXPONENTIAL VALUATION: ALTERNATIVE REPRESENTATION

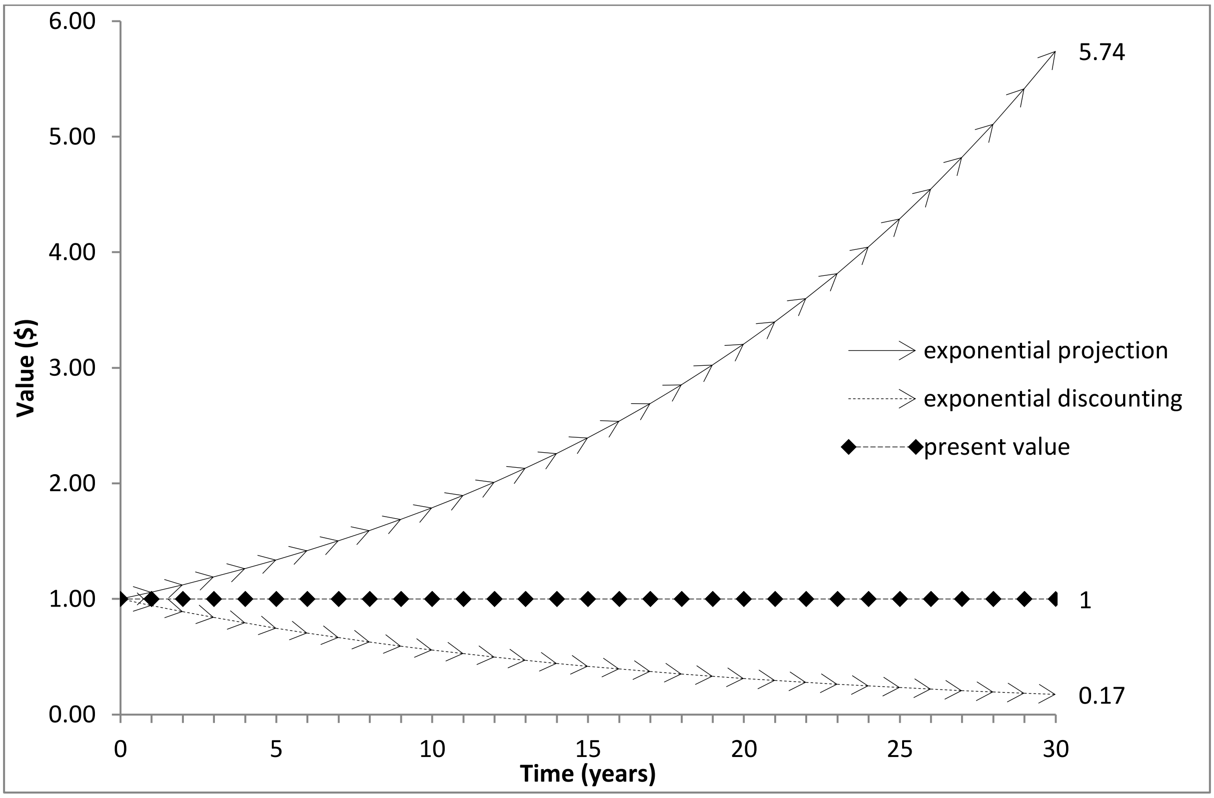


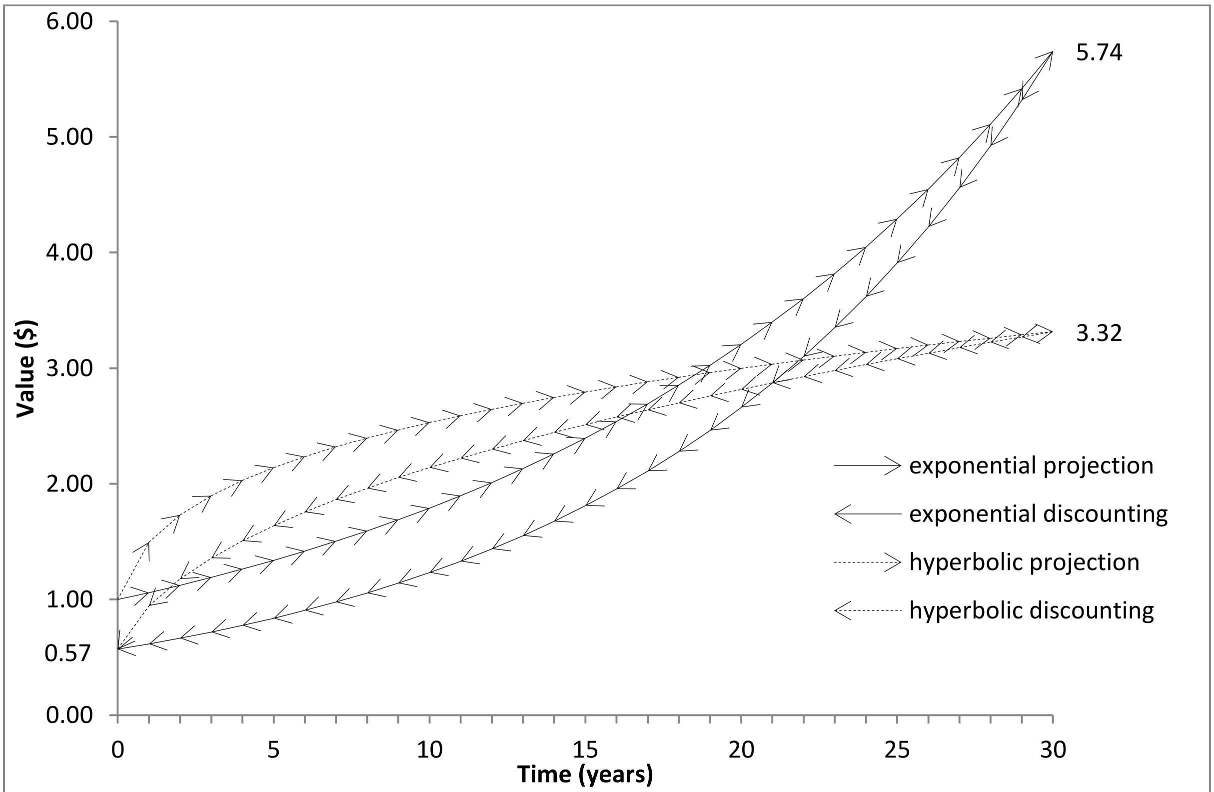
Chart 5 combines the exponential projection curve, in Charts 1 and 4, with the exponential discount curve, in Chart 2, to derive the "personal value curve" for all dates between 0 and 30 years. Since the thought investment is discounted at exactly the same rate as it is projected, the personal value curve confirms that whatever the projected value of the investment, personal value is always $1. This illustrates the influence of temporal neutrality on the personal valuation of a financial investment. So valued, $1 invested in bonds has the same value as $1 invested in equities, even though equities are riskier than bonds.

We are not always temporally neutral – indifferent about the timing of benefits and harms (Suhler and Callender, 2012). Sometimes, we have positive time preference – we prefer present pleasures (and future pain) to future pleasures (and present pain) of an equivalent magnitude. Sometimes, in contrast, we value the future over the present – we have negative time preference. We look at the influence of positive and negative time preference on personal valuation in the next two sections.

3. POSITIVE TIME PREFERENCE

Positive time preference is reflected in the use of a discount rate that is higher than the projection rate over the valuation period, i.e., we discount more heavily than when valuing with temporal neutrality. So, personal value is less than market value. Chart 6 combines the Chart 4 projection curves with steeper discount curves. As in Chart 4, an invested $1 is projected forward 30 years exponentially to $5.74 and hyperbolically to $3.32. Those projected values are each then discounted back, in the same way but at rates greater than their projection rates, to $0.57: $5.74 is exponentially discounted; and $3.32 is hyperbolically discounted.[12] In both cases, $1 thought invested today has a personal value today of $0.57.

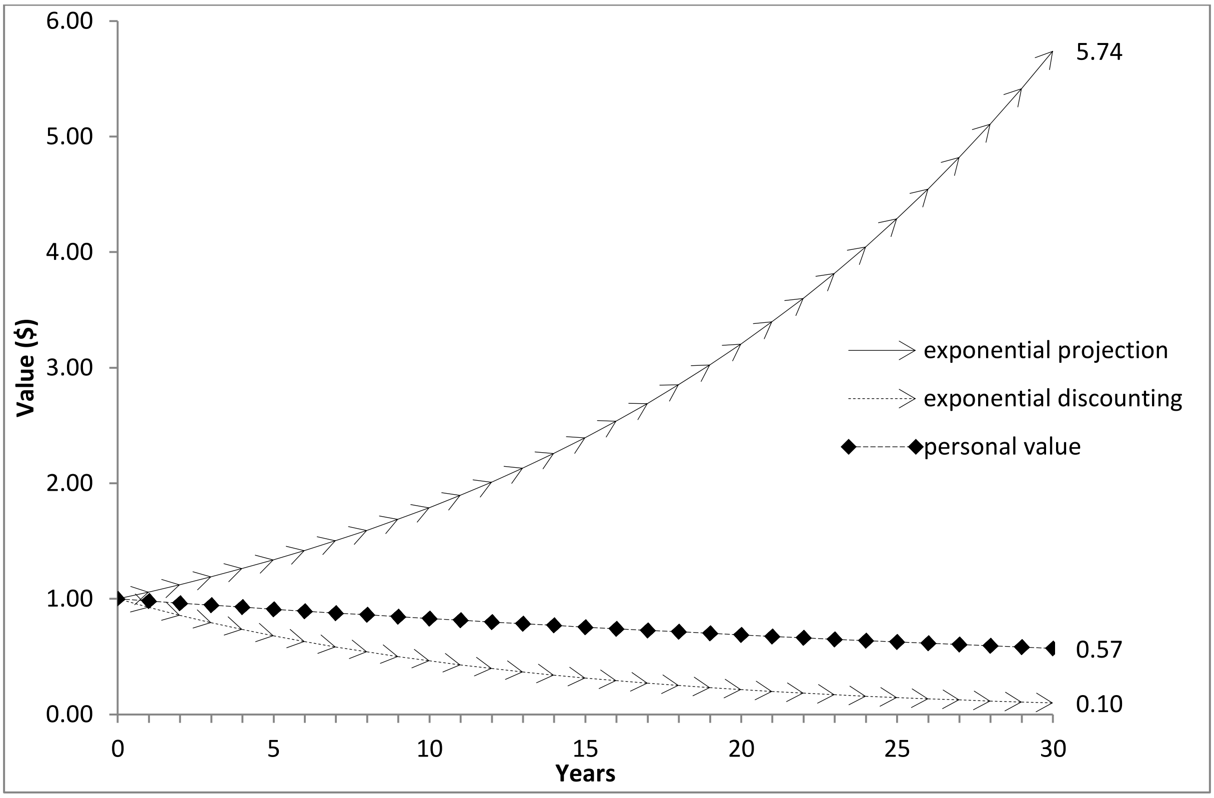
CHART 6: POSITIVE TIME PREFERENCE EXPONENTIAL AND HYPERBOLIC VALUATION



[12] Chart 6 assumes that R=8%, γ = 1 and α = 2.45. These parameters are set to give a personal value of $0.57 in both the exponential and hyperbolic cases. This is purely for expositional convenience.

Again for illustrative purposes, Chart 7 presents the exponential curves in Chart 6 in the format of Chart 5. $1 today is valued more highly than $5.74 in 30 years' time, even though a $1 invested today has a projected value of $5.74 in 30 years' time. This is the influence of positive time preference.

CHART 7: POSITIVE TIME PREFERENCE EXPONENTIAL VALUATION: ALTERNATIVE REPRESENTATION



A good introduction to some of the causes of positive time preference is given by Van Liedekerke (2004) who, in turn, draws on the work of Böhm-Bawerk (1921) and Fisher (1930). We build on that analysis here and, assuming that time preference, like discounting, is multi-causal or "multiply determined" (Bartels and Urminsky, 2011), consider five possible explanations: short-sightedness; impatience; weakly-connected temporal selves; existential uncertainty; and risk aversion. We need to consider these attributes in a relative sense, i.e., relative to those that determine temporally neutral valuation. For example, we will suppose that positive time preference valuations are more short-sighted than are temporally neutral valuations. When valuing financial investments, we can think of positive time preference as being equivalent to temporal neutrality adjusted for the effects of such attributes.

3.1 *Short-sightedness*

Some of us suffer from inadequacies in our "ability to imagine the future" (Loewenstein, 1992). Some of us have a "faulty telescopic faculty" (Pigou, 1920, cited by Frederick et al., 2002). Loewenstein (1992) uses the analogy of a driver's view of objects on the road to tease out the distinction between these two aspects of short-sightedness – on the one hand, distant objects may seem blurry and, on the other, objects may appear more distant than they actually are. Blurry vision implies inaccurate projecting – an inability to visualise the constant growth promised by the exponential projection curve provides one possible explanation for the flattening of the hyperbolic projection curve over time. Overestimation of the investment horizon, on the other hand, implies discounting over an excessive period. For example, if we overestimate the maturity period of the investment by, say, 5 years, we will discount over an extra 5 years.

3.2 *Excessive impatience*

Some of us experience psychological discomfort when asked to defer immediate gratification, even for a short period. We are impatient (Loewenstein, 1992, Olson and Bailey, 1981). Impatience can be due to a lack of foresight, to a weakness of will or self-control, to habit or to fashion (Van Liederkerke, 2004). Impatience implies excessively heavy discounting.

3.3 *Weakly-connected temporal selves*

The concept of a life as a series of psychologically connected temporal selves is a notion developed by philosophers, such as Parfit (1971, 1982 and 1984), and explored by economists and behavioural scientists, such as Strotz (1955-56) and Frederick (2003 and 2006). The psychological connections at the core of this concept include our memories, personal characteristics and interests, all of which contribute to the make-up of our personal identity.

Some of us have weakly-connected present and future selves. As Herschfield (2011) explains, the degree to which an individual feels disconnected from his or her future self should correlate with the degree to which that person discounts future rewards. The more a person's future self feels like a stranger, the more heavily that person might discount that stranger's future.

3.4 *Existential uncertainty*

The Epicureans' presumption of non-existence post-mortem (their belief that the soul dies with the body) imposes a finite time horizon on our existence and, as Olson and Bailey (1981) argue, a finite time horizon is consistent with positive time preference. So, too, is uncertainty as to the length of the horizon. A finite time horizon of uncertain length is, of course, a defining feature of human life. The "brevity and uncertainty of human life" (Loewenstein, 1992) means that we cannot know how long we will exist. If we believe that we might not be here when our investments mature, we might discount them.

3.5 *Above-average risk aversion*

Existential uncertainty is just one risk factor which might influence time preference. Many of us are risk averse (Andersen et. al., 2008). We discount the expected value of uncertain gains. We prefer a certain reward to an uncertain reward of equal expected value (Khaneman and Tversky, 1984). A highly risk-averse investor is likely to discount risky investments heavily. To such an investor, $1 invested in risk-free bonds is likely to be worth more than $1 invested in equities.

Risk aversion can help explain the heavy discounting of risky investments. But it can only explain that of riskless investments if such investments have uncertain value psychologically. Heavy discounting of a riskless investment is more likely to be a characteristic of risk-seeking individuals. This explains, too, the use of high discount rates by gamblers and those with risk-seeking behaviours such as alcohol and drug abuse (Chabris et. al., 2008). These are people whose temporal selves are loosely connected – they care little for their future selves.

4. **NEGATIVE TIME PREFERENCE**

Negative time preference is reflected in the use of a discount rate lower than the projection rate over the valuation period, i.e., we discount less heavily than when valuing with temporal neutrality. So, personal value exceeds market value. Chart 8 combines the Chart 1 projection curves with less steep discount curves. An invested $1 is projected forward 30 years exponentially to $5.74 and hyperbolically to $3.32. Those projected values are each then discounted back, in the same way but at rates less than their projection rates, to $1.77: $5.74 is exponentially discounted; and $3.32 is hyperbolically discounted.[13] In both cases, $1 thought invested today has a personal value today of $1.77.

CHART 8: NEGATIVE TIME PREFERENCE EXPONENTIAL AND HYPERBOLIC VALUATION

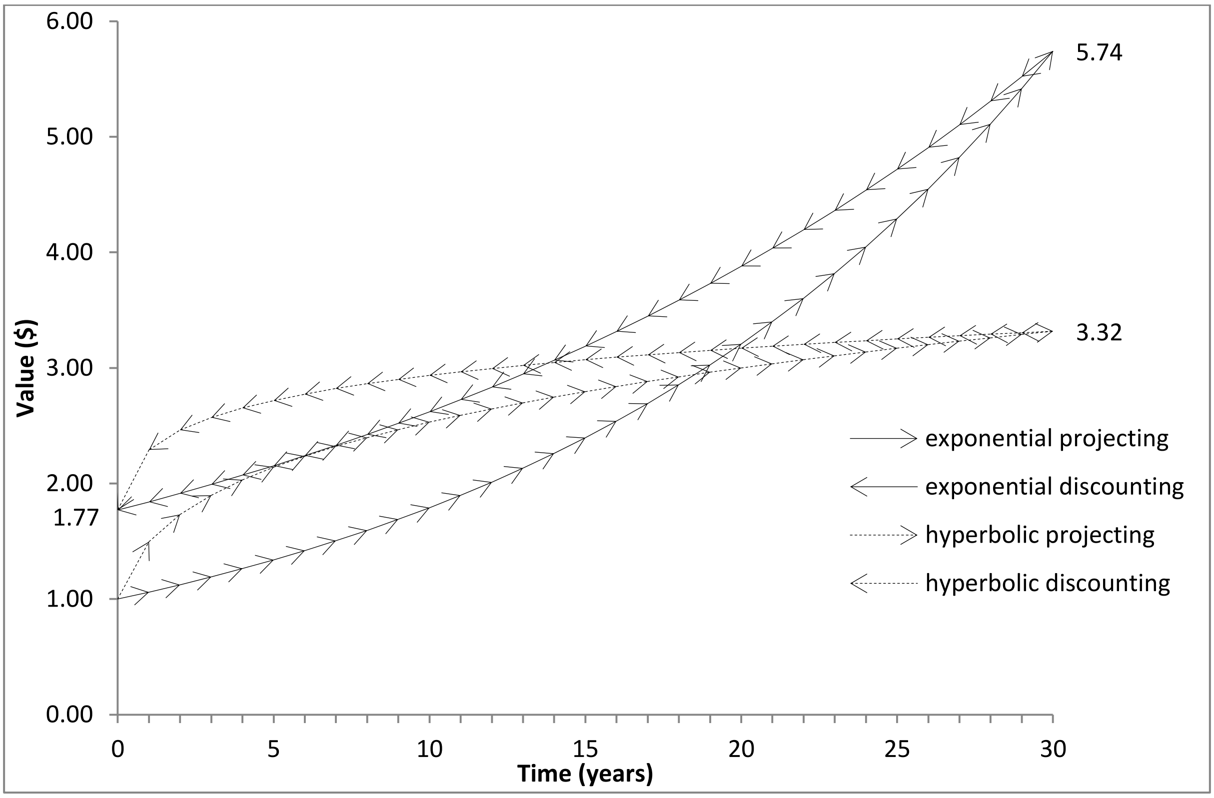
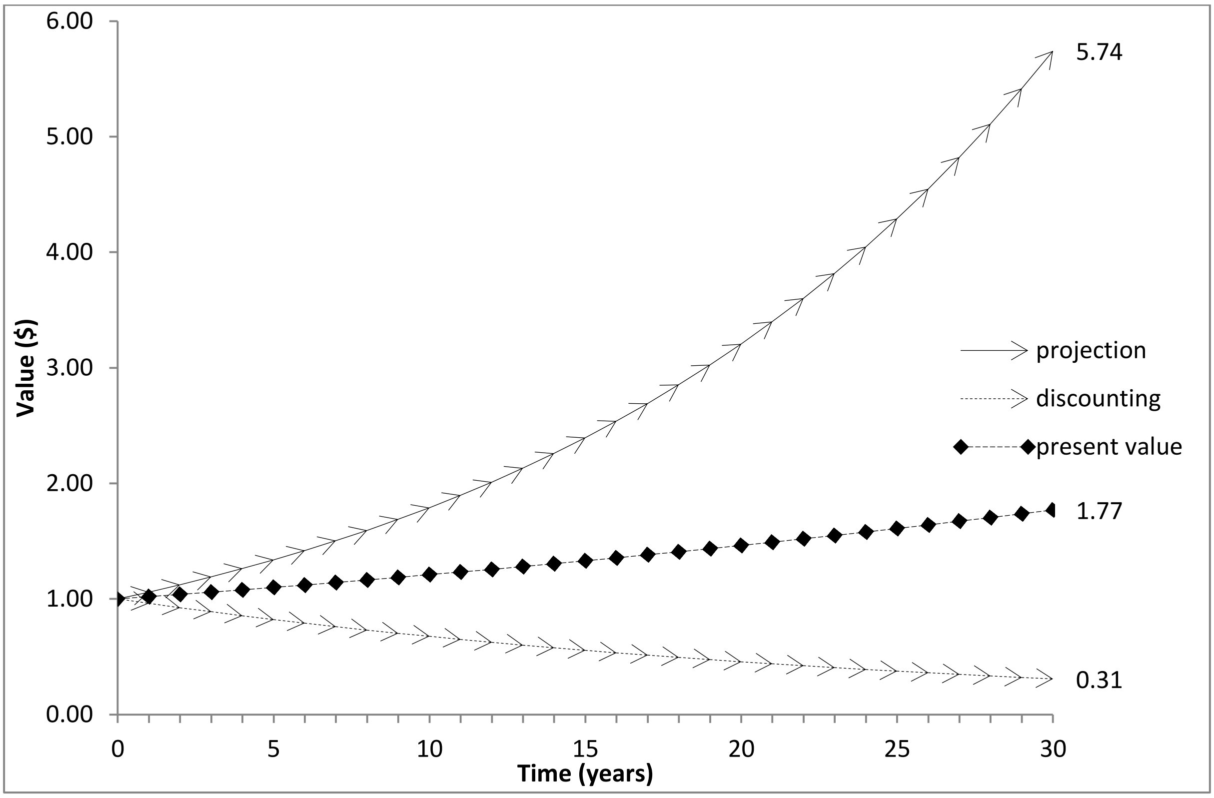


Chart 9 presents the exponential curves in Chart 8 in the format of Charts 5 and 7. The personal value of the investment rises as its duration increases. $1 today is valued at less than $5.74 in 30 years' time even though a $1 equity investment today is projected to grow to $5.74 in 30 years' time. This is the influence of negative time preference.

[13] Chart 8 assumes that R=4%, γ = 1 and α = 8.9.

CHART 9: NEGATIVE TIME PREFERENCE EXPONENTIAL VALUATION: ALTERNATIVE REPRESENTATION



Negative time preference has been linked to a desire for improving sequences of outcomes which, in turn, can be attributed partly to anticipation (Loewenstein and Prelec, 1991). Pleasure from anticipation is enhanced if the best comes last. Pleasure from anticipating the future and its rewards includes a "bequest motive" (Loewenstein, 1992) – a spirit of altruism which can mean enjoying giving for its own sake (Cowen and Parfit, 1992) or which can be personally motivated, as by the desire to build a family dynasty, or socially motivated, as by a concern for inter-generational welfare and for the protection of the environment. Negative time preference is consistent with an extended or infinite time horizon – such as that needed to accommodate a family dynasty or a belief in post-mortem existence.

Negative time preference is thus associated with far-sightedness and with a desire for accumulation (Loewenstein, 1992). It is a characteristic of those who have self-control and can resist, or abstain from, immediate gratification (Keinan and Kivetz, 2008). And, some of us enjoy wealth for its own sake. As with positive time preference, habit and fashion can also be a cause of negative time preference (Van Liedekerke, 2004).

It might be expected that individuals who discount more lightly than they project do so because their temporal selves are strongly connected. Indeed, research confirms that a strong psychological connection between the temporal selves facilitates saving – individuals who anticipate that their future personal identity will overlap considerably with their current identity tend to accumulate more financial assets than do those who sense little such overlap (Hershfield et al., 2009).

We might expect, too, that an individual who discounts lightly would not suffer existential uncertainty or excessive risk aversion but, instead, might be more of a risk seeker. A risk-seeking investor might be happy, for example, to discount an equity investment at the risk-free bond discount rate. So valued, S1 worth of equities would be worth more than $1 worth of bonds.

Uncertainty about the future can, however, be "double-edged": it can cause the future to be valued more than the present, as well as less (Olson and Bailey, 1981). Risk aversion, for example, can encourage "saving for a rainy day" (Olson and Bailey, 1981) and existential uncertainty can incentivise financial provision for an unexpectedly long life.

5. HYBRID VALUATION

Sections 2-4 explore pure exponential valuation and pure hyperbolic valuation (i.e., the same valuation method is used both to project and to discount). In this section, we explore hybrid valuation – the use of one method to project and another to discount.

Chart 10 illustrates hybrid valuation where projection is exponential and discounting is hyperbolic. The $1 investment is exponentially projected to: $1.79 after 10 years and to $5.74 after 30 years. When discounted hyperbolically: $1.79 in 10 years' time has a personal value of $0.71; and $5.74 in 30 years' time has a personal value of $1.73. Valuation over the 10-year horizon reveals positive time preference, but valuation over the 30-year horizon reflects negative time preference. At some point during year 19, valuation is temporally neutral. If the financial markets project exponentially, individuals who discount hyperbolically will value $1 invested in short-term securities at less than $1 invested in, otherwise similar, long-term securities.

Chart 11 illustrates hybrid valuation where growth is hyperbolic and discounting is exponential. The $1 investment is projected hyperbolically to: $2.53 after 10 years; and $3.32 after 30 years. When discounted exponentially: $2.53 in 10 years' time has a personal value of $1.41; and $3.22 in 30 years' time has a personal value of $0.58. Valuation over the 10-year horizon reveals negative time preference, but valuation over the 30-year period reflects positive time preference. Again, around about year 19, valuation is temporally neutral. If most people demand higher rates of return for short investment periods than for long ones, those who discount the future at a constant rate will value short-term securities over long-term securities (Lowenstein and Prelec, 1992).

CHART 10: HYBRID VALUATION: EXPONENTIAL PROJECTION WITH HYPERBOLIC DISCOUNTING

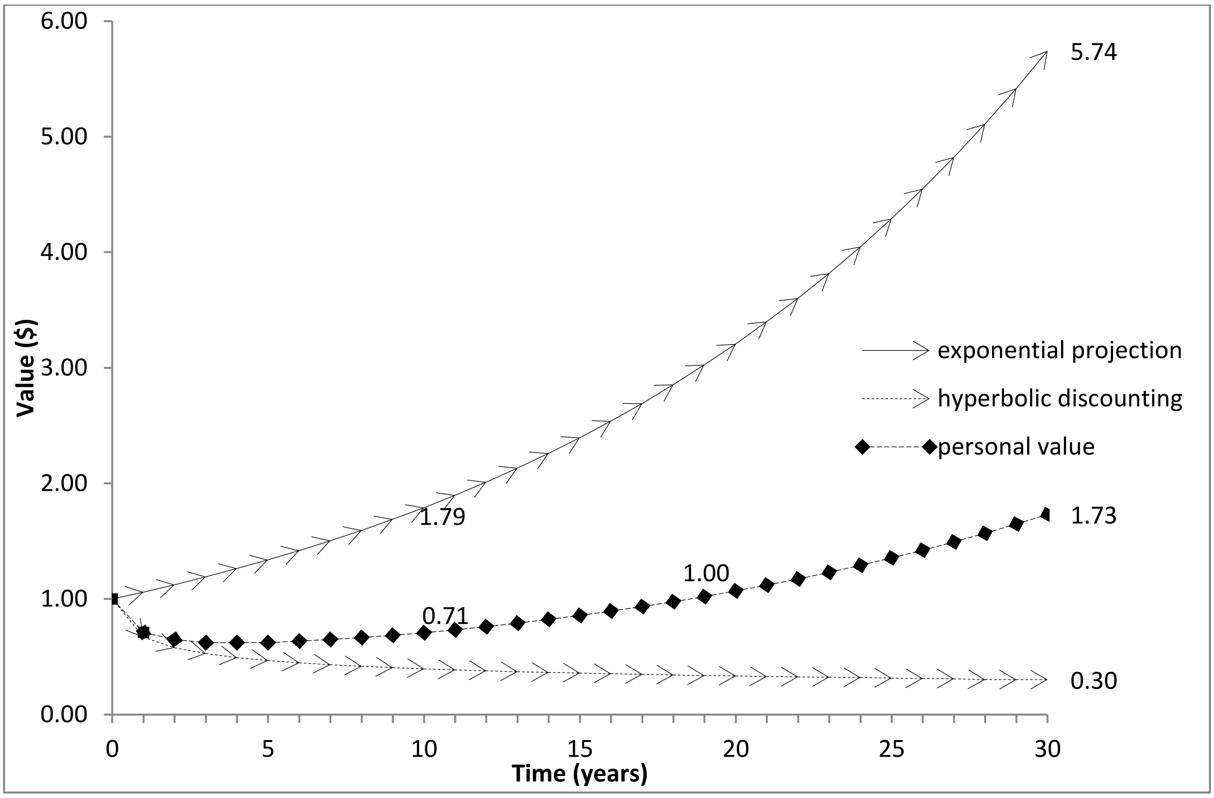
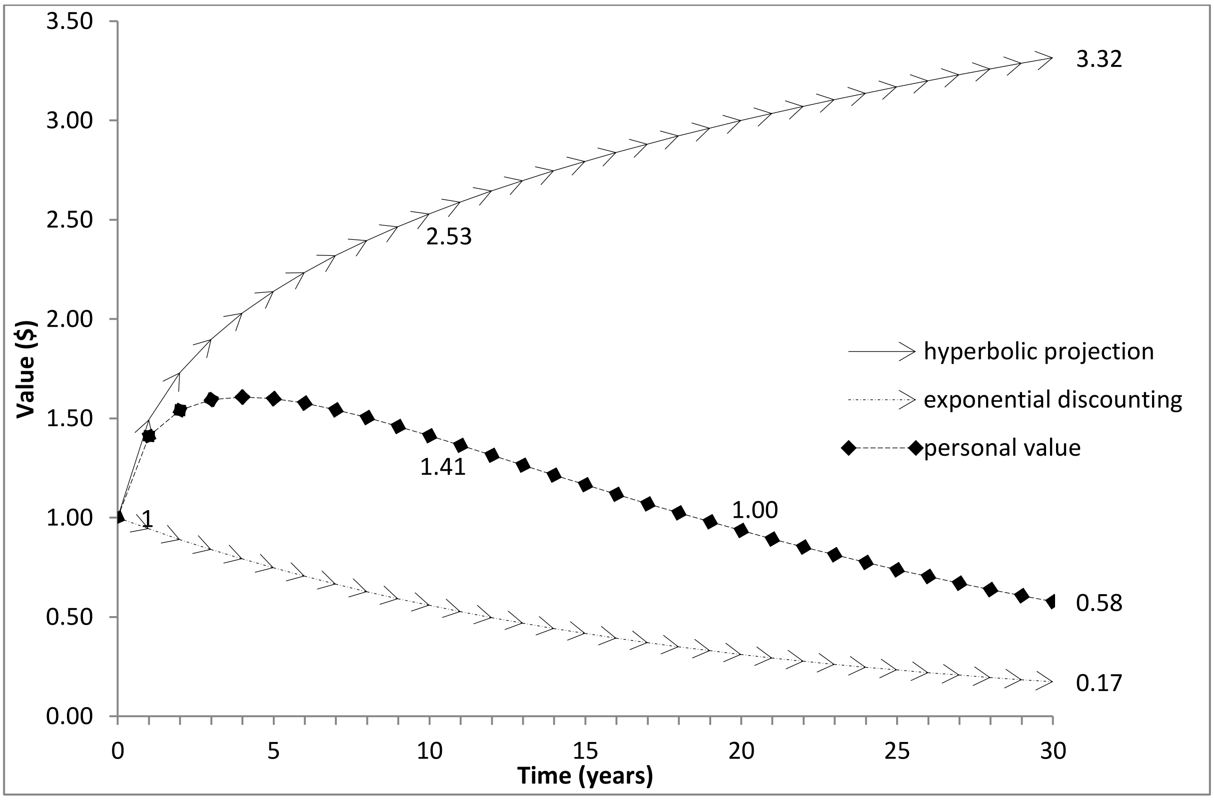


CHART 11: HYBRID VALUATION: HYPERBOLIC PROJECTION WITH EXPONENTIAL DISCOUNTING



6. VALIDATING THE FRAMEWORK

Taken together, the thought investments, set out in the preceding four sections, form the basis of a conceptual framework for understanding the influence of time preference on the personal valuation of financial investments. In this section, we consider how we might test the framework.

Empirical time preference studies typically invite subjects to choose between, or compare, smaller sooner rewards and larger later rewards. From the responses to such questions, researchers can infer personal discount rates and methods (Coller and Williams, 1999, Anderson et. al., 2008, Chabris et. al., 2008). A personal discount rate is deemed to be a measure of an individual's time preference (Frederick et al., 2002, Chabris, 2008) and the method used an indicator of the consistency of time preference over time. The higher the discount rate, the greater is the preference for the reward sooner rather than later.

Such time preference experiments are mental time travel exercises. Mental time travel allows us to mentally pre-live the future ("prospection") or re-live the past ("retrospection") (Suddendorf and Corballis, 2007). Mental time travel theory has traditionally viewed prospection as identical to retrospection, save for the direction of travel (Van Boven et al., 2008). Time preference research has traditionally taken the same view of projecting and discounting.[14] Recent research, however, reveals that, for many of us, the ways in which we mentally represent the future and the past are not the same (Kane et al., 2012). Prospection differs, in context and experience, from retrospection (Van Boven et al., 2008). Some researchers acknowledge, too, that projecting and discounting might be psychologically distinct. Doyle (2013), for example, recognises that, while their underlying formulae might be mathematically equivalent, the mental operations underlying projecting and discounting might differ.[15]

Our valuation framework draws a distinction between projecting and discounting. To test it, we need to elicit and compare projection rates and discount rates.

Eliciting projection rates might take the form of the following questions (based on Wang, Rieger and Hens, 2011):

> *"Please consider the following alternatives*
>
> A. a payment of $100 now
>
> B. a payment of $X in one year from now
>
> X has to be at least $_, such that B is as attractive as A.
>
> *Please consider the following alternatives*
>
> A. a payment of $100 now

[14] Mitchell and Utkus (2004), for example, entitle their diagram, reproduced here as Chart 2, "Exponential versus Hyperbolic Discounters: Growth of $1 Over Time".
[15] He notes too, analogously, that while 8! = 1·2·3·4·5·6·7·8 = 8·7·6·5·4·3·2·1, those adopting the former definition (involving an ascending sequence of numbers) tend to give lower estimates of the value of 8! than if they are presented with the mathematically equivalent descending sequence definition (Doyle, 2013, citing Tversky and Kahneman, 1974).

B. a payment of $X in 10 years from now

X has to be at least $_, such that B is as attractive as A."

Eliciting discount rates might take the form of the following questions:

"You have $100 safe in your house but you have forgotten where it is. Someone will tell you where it is in a year's time. What fee will you pay now to be told where it is today?

"You have $100 safe in your house but you have forgotten where it is. Someone will tell you where it is in ten years' time. What fee will you pay now to be told where it is today?

7. CONCLUSION

In this paper, we explore the influence of time preference on the personal valuation of financial investments. In a series of thought investments, an invested $1 is projected forward and discounted back. The thought investments illustrate the effects of three expressions of time preference on exponential and hyperbolic valuation:

- temporal neutrality – in which the discount rate matches the projection rate over the valuation period;
- positive time preference – the discount rate exceeds the projection rate over the period; and
- negative time preference – the projection rate exceeds the discount rate.

We explain how an individual's personal characteristics can help influence time preference. We suggest that the attributes which might explain positive time preference include short-sightedness, impatience, weak psychological connections between the temporal selves, existential uncertainty and risk aversion, while those that might determine negative time preference include self-control, altruism, strong psychological connections and an appetite for risk. These lists are not exhaustive, nor are these attributes necessarily mutually exclusive. Their interaction will determine time preference.

A thought-invested $1 has a personal value of $1 when valued with temporal neutrality. So valued, $1 invested in bonds has the same personal value as $1 invested in equities. On the other hand, as we explained when illustrating the influence of positive time preference, to a highly risk-averse investor, $1 invested in risk-free bonds is likely to be worth more than $1 invested in equities. Contrast this, as we explained when illustrating the influence of negative time preference, with a risk-seeking investor who is likely to value the S1 equity thought investment over the $1 bond thought investment**.**

One implication of the thought investments is that individuals will: undertake investments when valuation reflects negative time preference (personal value exceeds market value); refrain from investing when valuation reflects positive time preference (market value exceeds personal value); and be indifferent when valuation reflects temporal neutrality (personal value equals market value).

How might personal valuation be influenced by the duration of an investment? As Chart 10 suggests, if the financial markets project exponentially, individuals who discount hyperbolically (short-term rate higher than long-term rate) will value $1 invested in short-term securities at less than $1 invested in, otherwise similar, long-term securities. Conversely, as Chart 11 suggests, if most people demand higher rates of return for short investment periods than for long ones, those who discount the future at a constant rate will value short-term securities over long-term securities (Lowenstein and Prelec, 1992).

Such preferences might be a feature, too, of purely exponential or hyperbolic valuation – if, for example, equities are perceived to be risky in the short-term, but safer over the long-term, a risk-averse individual might value them at less than market value over a short investment period, but at more than market value over a longer horizon. Research by Laury et. al., (2012) suggests, however, that, while subjects will increasingly prefer a larger, later value over a sooner, smaller value as the later value increases, a small percentage of us *always* prefers the sooner value and a similar small proportion *always* prefers the later value.

In section 5 of this paper, we outline possible empirical research to validate the conceptual framework outlined in this paper. We leave such experimentation to future work. Nevertheless, we know that in reality personal valuations along the lines discussed in this paper do happen. At the conference one of the authors attended all those years ago, it was quite clear that practising actuaries at that time could quite happily switch a pension fund's bond holdings, valued at $100 million, into equities and value those equities at $120 million and the Guidance Notes of their profession equally happily allowed such off-market valuations.[16]

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[16] See, e.g., Guidance Note 9 of the Institute and Faculty of Actuaries.

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