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Gamma discounters are short-termist

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ABSTRACT

Using the gamma discounting argument of Weitzman (1998, 2001) when future interest rates are uncertain, several countries have decided to base their investment and sustainability policy evaluation on a decreasing term structure of discount rates. We show that this interpretation of the gamma discounting argument is in fact equivalent to the Local Expectations Hypothesis, a hypothesis globally rejected in empirical finance. We also show that gamma discounters are time-inconsistent and short-termist when shocks to economic growth are persistent. This is because they fail to account for the correlation between future consumption levels and spot interest rates.

1. Introduction

The exponential nature of discounting at almost any reasonable positive discount rate implies that, when comparing alternative investments, their long-term impacts do not really matter. This so-called "short-termism" intrinsic to standard discounting has been much criticized, in particular in the context of climate change. However, economic theory does not constrain discount factors to be exponential, or discount rates to be constant. Over the last 15 years or so, the United Kingdom (HM Treasury, 2003), France (Lebègue, 2005) and Norway (Official Norwegian Report, 2012) have used decreasing discount rates for the evaluation of public policies, specifically to estimate the social cost of carbon. In the U.K. for example, the term structure of discount rates ranges from 3.5% for the short term to 1% for long maturities.[2] In 2006, the OECD published a cost-benefit manual (Pearce et al., 2006) that endorses decreasing discount rates. Moreover, the U.S. could consider a revision of the long-term discount rate by allowing it to be smaller than the short-term one (Arrow et al., 2013).

Weitzman (1998, 2001) provided a simple argument that played a key role in the change of the evaluation rules prevailing in these countries. If r is the compound interest rate associated with maturity t, a trivial arbitrage argument states that the value of a sure benefit occurring in t years should be equal to $\exp(-rt)$. If r is uncertain, Weitzman (1998, 2001) proposed to value this sure benefit as the expectation of this discount factor. Because the discount factor is increasingly convex with t, this Expected Discount Factor Hypothesis (EDFH) generates certainty-equivalent discount rates that are decreasing in maturities. The intensity of this effect depends upon the distribution of r. It is easy to verify that the discount rate for short maturities is equal to the mean of r, whereas the discount rate tends to the minimum of the support of r when the maturity t of the benefit tends to infinity. Because Weitzman (2001) used a gamma distribution for r to compute certainty equivalents, this approach is often referred to as "gamma discounting".

Depending upon the nature of the uncertainty surrounding r, there have been various interpretations of this argument in the literature. We review these interpretations in Section 5 of this paper. Following, for example, Newell and Pizer (2003), Groom et al. (2007), Gollier et al. (2008), and Farmer et al. (2014), a realistic interpretation is that future short interest rates evolve stochastically so that the compound interest rate is uncertain. In this paper, we show that the EDFH approach — alias gamma discounting — is problematic under this interpretation. First, we show that it is linked to the Expectations Hypothesis used in

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[2] In France, it ranges from 4% to 2%.

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finance to price bonds, at least since Macaulay (1938). One of the many forms of this hypothesis is the Local Expectations Hypothesis (LEH) introduced by Cox et al. (1981). The LEH states that conditional expected rates of return on bonds of all maturities over the next period are all equal. We show that the EDFH and LEH hypotheses are strictly equivalent to each other. However, Cox et al. (1981) and Gilles and Leroy (1986) have shown that the LEH is compatible with the consumption-based Capital Asset Pricing Model (CAPM) only if the growth rate of consumption over the next period is certain. This is unrealistic, as it would imply for example that risky assets would bear a zero risk premium at equilibrium. Moreover, the empirical literature on bond pricing has globally rejected the LEH.[3]

Both the EDFH and LEH support gamma discounting, and are often wrongly associated with risk neutrality since LEH means that there is no term premium associated with holding long bonds, although they are riskier for short-lived investors. We show in this paper that risk-neutral evaluators who use gamma discounting to evaluate long projects face a time consistency problem. Under gamma discounting, the value today of a safe benefit maturing in t years is not equal to the present value today of the expected value next year of that benefit.

Finally, we compare the gamma discount rates to the efficient discount rates prevailing in a Lucas economy with a risk-averse representative agent. We simultaneously characterize the distribution of future spot interest rates and the term structure of efficient discount rates today, and compare it to the term structure of gamma discount rates. As a preview of the main results of the paper, suppose that shocks to the growth rate of consumption are persistent, as documented for example by Bansal and Yaron (2004). This implies that future consumption is positively correlated with future spot interest rates. Because the discount factor is inversely related to the discount rate, the present value evaluated at t-1 of a sure benefit occurring at t is negatively correlated with consumption at t-1. In other words, transferring to the present a future sure benefit through a sequence of short-term loans has a negative consumption-based CAPM beta.[4] The gamma discounting rule ignores this fact by implicitly assuming that this strategy has a zero beta. The long gamma discount rate is thus too large, yielding an evaluation error that is qualitatively equivalent to discounting at the risk-free rate a cash flow with a negative consumption-based CAPM beta. Gamma discounting is short-termism.

In Section 2, we define EDFH and show that the risk-neutral users of this pricing rule face a time-consistency problem. We demonstrate the equivalence between EDFH and LEH in Section 3. Our main results are presented in Section 4, in which we compare the term structure of gamma discount rates with that of socially efficient discount rates derived from a normative asset pricing model, à la Lucas. Section 5 is devoted to a short discussion of the existing literature on gamma discounting. Section 6 concludes.

2. Risk-neutral gamma discounters are time-inconsistent

Let $p(t,\tau)$ denote the price at date t of a zero-coupon bond that matures at date $\tau \geq t$. This asset is a claim on one monetary unit at that future date, so that $p(\tau,\tau)=1$. Notice that $p(t,\tau)$ could be reinterpreted as the discount factor to be used at date t to discount a sure benefit maturing at date τ.The one-period discount — or interest — rate r_t at date t is such that:

$$p(t,t+1) = \exp(-r_t). \quad (1)$$

Future interest rates are in general uncertain. We are interested in determining the relationship between the present value $p(t,\tau)$ and the sequence of short interest rates r_j, $j\in\{t,\tau-1\}$that will prevail between t and τ. Weitzman (1998, 2001) proposes the following Expected Discount Factor Hypothesis (EDFH). For all t and all $\tau \geq t+1$:

$$EDFH: \quad p(t,\tau) = E_t\left[\exp\left(-\sum_{j=0}^{\tau-t-1} r_{t+j}\right)\right], \quad (2)$$

where E_t is the expectation operator conditional to all information available at date t. The left-hand side of this equation is the long discount factor $p(t,\tau)$, whereas the right-hand side is the expectation of the product of the future discount factors $p(t+j,t+j+1)$. The EDFH proposed by Weitzman means that the long discount factor equals the expectation of the future short discount factors. Weitzman's gamma discounting rule is a specific application of the EDFH rule in which (i) $r_{t+j}=r$ for all $j\geq 0$, and (ii) $r$has a gamma distribution. Henceforth, we refer to gamma discounters as people who use the EDFH rule.

The EDFH is wrongly associated with risk neutrality since it is supported by the idea that investment projects should be compared on the basis of their expected net present value. In this section, we show that risk-neutral gamma discounters face a time inconsistency problem. To see this, consider an asset A that generates a single unit benefit at date $\tau>0$ and an economy in which investors are gamma discounters. Each individual initially holds one unit of asset A. At time $t=0$, gamma discounters who want to hold this asset to maturity would value it as:

$$V_0^d = E_0\left[\exp\left(-\sum_{j=0}^{\tau-1} r_j\right)\right]. \quad (3)$$

This is the direct approach to gamma pricing. An indirect approach would consist of pricing this asset by backward induction. Let us contemplate the possibility of selling the asset at some date $t\in]0,\tau[$. The equilibrium price of this asset at that date must be equal to:

$$V_t = E_t\left[\exp\left(-\sum_{j=t}^{\tau-1} r_j\right)\right]. \quad (4)$$

Because information available at date t is uncertain seen from date 0, V_t is uncertain. Suppose now that gamma discounters are risk-neutral, as suggested by their use of the EDFH rule to price assets. Therefore, gamma discounters should perceive holding asset A as equivalent to holding another asset B which would deliver a single sure benefit $\overline{V} = E_0 V_t$ at date t. Using the gamma pricing rule again to value this strategy yields a price today of:

$$\begin{aligned} V_0^i &= E_0\left[\exp\left(-\sum_{j=0}^{t-1} r_j\right)\right] \quad \overline{V} \\ &= E_0\left[\exp\left(-\sum_{j=0}^{t-1} r_j\right)\right] E_0\left[\exp\left(-\sum_{j=t}^{\tau-1} r_j\right)\right]. \end{aligned} \quad (5)$$

From Eqs. (3) and (5), we see that the direct and indirect approaches only give the same valuation ($V_0^d = V_0^i$) if future interest rates are serially uncorrelated, which is an uninteresting case. This discrepancy between the direct valuation approach and the indirect approach by backward induction means that gamma discounters are time inconsistent. For example, this means that they are a free cash machine for arbitragers. Suppose for example that V_0^d is larger than V_0^i. Then, consider an arbitrage strategy consisting in three trades on this market at date 0: First, sell them asset A at price V_0^d. Second, buy asset B at price V_0^i. Finally, sell a contract C that promises to deliver $\overline{V}$at t against the payment of 1 at τ. Risk-neutral gamma discounters are arguably ready to sell this last contract at a zero price, since $\overline{V}$ is the expected value for them at t of a unit

[3] See for example Froot (1989): "If the attractiveness of an economic hypothesis is measured by the number of papers which statistically reject it, the expectations theory of the term structure is a knockout." Notice however that this empirical literature was mostly interested in *nominal* interest rates, whereas our concern in this research is about *real* discount rates. Shiller (1979) and Bekaert and Hodrick (2001) are two classical references for the testing of Expectations Hypotheses.

[4] The CCAPM beta of an asset is defined as the elasticity of its cash-flow to change in aggregate consumption. It measures the contribution of this asset to the aggregate risk in the economy.