Journal of Forest Economics 26 (2017) 1–8

Contents lists available at ScienceDirect

Journal of Forest Economics

journal homepage: www.elsevier.com/locate/jfe

Optimal rotation with differently-discounted benefit streams

Colin Price

90 Farrar Road, Bangor, Gwynedd LL57 2DU, United Kingdom

ARTICLE INFO

Article history:
Received 29 September 2016
Accepted 6 October 2016
Available online 25 December 2016

JEL classification:
Q230

Keywords:
Differential discount rates
Optimal rotation
Terminal values
Non-consumptive values

ABSTRACT

The case is often now made that discount rates should decline with time. Underlying reasons include that some kinds benefit (or cost) might be discounted at a lower rate than that used for others: in particular, that rates for carbon values and environmental amenities might be less than that for timber. A lengthening sequence of rotations then arises, whether the benefits are consumptive ones realised at the rotation end, or non-consumptive ones whose annual value increases through the rotation. A timber discount rate lower than that for non-consumptive benefits leads to a shortening sequence of rotations. The results differ importantly from those of discounting all benefits and costs at a reducing rate through time.

Introduction

A declining discount rate, particularly for public decisions, has been much discussed over the past few years (e.g. Weitzman, 1998; Newell and Pizer, 2004). It has been mandated for public project appraisal in the UK (HM Treasury, 2003), France (Lebègue et al., 2005), Denmark (Finansministeriet, 2013) and Norway (Det Kongelige Finansdepartment, 2014). Sweden and the Netherlands are also considering such a mandate.

At a meeting of the Scandinavian Society of Forest Economics (Price, 2008), I presented a tentative model of how an optimal sequence of lengthening rotations could be calculated for these circumstances in which the discount rate declined through time. The solution protocol for the optimal sequence under declining rates was rather unstable, but a more successful model was produced for the Faustmann III symposium (Price, 2011). That paper also explored the reasons put forward for declining discount rates, and reviewed some criticisms of those arguments. There is a fuller critique in Price (2004).

A more convincing – though still contested – case can be made for applying different discount rates to different kinds of benefit (or cost). This too causes rotation length to change through time, since the benefits to which the lower discount rate is applied will have greater influence as later rotations unfold.

An earlier version of this paper was presented at the 2012 meeting of the Scandinavian Society of Forest Economics, and eventually appeared as Price (2015). It has been revised, with support from some more recent references, and with more explanation of the solution protocol.

Differentiated discount rates

As an alternative to the popular illusion that *passage of time itself* is the mediator of declining discount rates, one could simply analyse segregated streams of benefit and cost, using differentiated discount rates –

E-mail address: c.price@bangor.ac.uk

http://dx.doi.org/10.1016/j.jfe.2016.10.001

a major factor in bringing an apparent decline through time of overall discount rates. The focus being thus moved to the *causes* of different rates rather than the *effects*, there is less potential to draw spurious conclusions or to respond inappropriately to changing circumstances.

It has long been argued that benefits arising from the *presence* of a forest, and *increasing through with crop age*, would lengthen rotations (Hiley, 1956). Benefits in this category include landscape and recreation values, habitat for (some kinds of) flora and fauna, storage of carbon, and generation of non-timber forest products. Formal introduction of the effect into economic models of rotation is usually attributed to Hartman (1976). Those who have discussed this further include Strang (1976), Calish et al. (1978), Johansson and Löfgren (1985), and Price (1987). Krutilla and Fisher (1972) and Fisher and Krutilla (1975) have argued for the increasing importance of such values in natural resource economics generally. But the *combination* of these two effects – increasing importance of non-consumptive values, and their ongoing effect on rotation – seems to have been little treated.

Sjølie et al. (2013) have discussed the effects of different rates of discount for timber and carbon on levels of investment and rotation length during the present century. The effect on successor rotations was not further examined. Ekholm (2016) used an increasing price for carbon, which has an equivalent effect to using a lower carbon discount rate. He finds that this (usually) increases the present forest rotation. He also argues that subsequent rotations will be further extended, but does not calculate the magnitude of this effect.

This paper explores how the whole sequence of rotations, over 1000 years, is affected by differentials of discount, for a wider set of products, with various projected profiles of value through time.

The model

The following demonstration of the rotational effect of differential discount rates is based on a model with the following reasonable characteristics.

- Timber has no net sale value until a given age.
- Thereafter revenue per hectare rises rapidly at first, then at a decreasing rate, according to the following:

$$[\text{Revenue}_{\text{Age}}] = a \times \sin\left(\frac{[\text{Age}] - b}{[\text{Age}] - b + c}\right)^{d}$$

- where a is the asymptote of revenue, b is the age at which positive revenue is first achieved, c determines rate of approach to the asymptote and d is a shape parameter. The equation produces a flexible and realistic shape. The parameters are constant throughout the cases treated below: $a = €30{,}000$, $b = 20$ years, $c = 30$ years, $d = 2.5$. That these parameters give a reasonable timber revenue curve may be checked by inspecting Fig. 2 below. If parameters are changed, the results change in the expected direction, yielding similar profiles of rotation length to those shown in Figs. 1 and 3–7.
- First formation cost is common to all rotations, so has no influence. Regeneration cost of €800 per hectare is deducted from each final revenue. Regeneration cost is discounted at the same rate as timber revenues, though it would be possible to use a different discount rate for that too, with its own effects on optimal rotation.

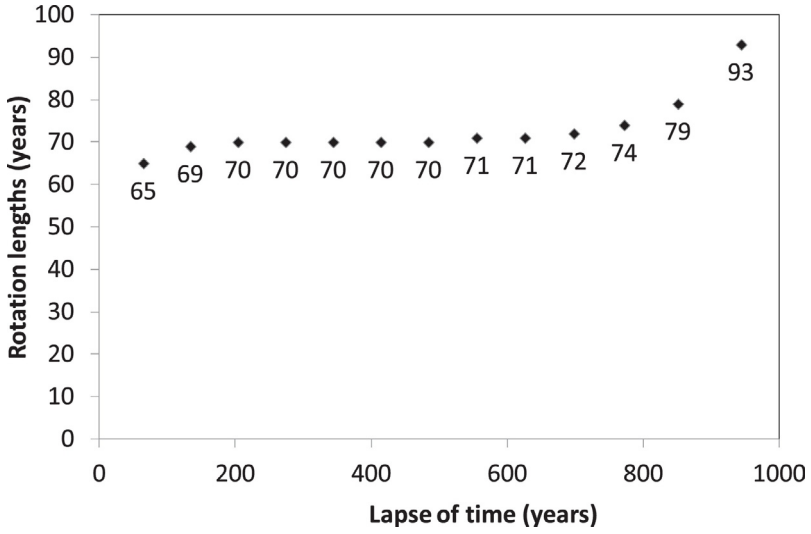

Fig. 1. Lengthening rotation with two terminal benefits.