Empirical evidence for time-declining social discount rates: the role of intermediate ecosystem services in production

Xueqin Zhu [a], Mark Koetse [b], Hermen Luchtenbelt [a], Jeroen Brandsma [b]

[a] Wageningen University and Research, Environmental Economics and Natural Resources Group
[b] Institute for Environmental Studies, Vrije Universiteit Amsterdam

Abstract

Recent research shows that ecosystem services in consumer utility are becoming scarce relative to produced consumption goods and services, and substitutability between the two is limited (e.g. Baumgärtner et al., 2015; Koetse et al., 2018). According to economic theory this implies that the relative price of final ecosystem services increases, and within a Ramsey optimal growth framework this means that in a social cost benefit analysis lower discount rates should be applied to investment projects on ecosystem services than to those on produced consumption goods and services (Weikard and Zhu, 2005; Hoel and Sterner, 2007). Interestingly, some authors studied the time-behaviour of the social discount rate, but different mechanisms are used. While Hoel and Sterner (2006) and Traeger (2011) find that limited substitutability between ecosystem services and other consumption goods and services in utility would require non-constant discount rates over time by using a CES utility function, other authors suggest time-declining discount rates by considering the uncertainty of future economic growth (Gollier, 2002; Groom and Hepburn, 2017).

An important extension to these analyses and insights is related to the role of intermediate ecosystem services, or more specifically ecosystem services that are used in the production of consumption goods and services. In a theoretical study, Zhu et al. (2019) show that when the growth rate of ecosystem services is relatively low, and if the substitution potential between ecosystem services and other input factors is imperfect, the social discount rate should decline over time. However, to what extent the intermediate ecosystem services in production would affect the social discount rate requires empirical estimation of the growth rates of ecosystem services and the elasticities of substitution between ecosystem services and other inputs in production. The existing literature only provides very scant information on these. The purpose of this paper is therefore to provide some empirical evidences of the low growth rates and the limited substitutability of ecosystem services and to show how we can use this information to guide the determination of the social discount rate. We do this in three steps:

- We empirically assess growth rates of essential ecosystem services (or indicators thereof) as inputs in production;
- We derive empirical evidence for the potential for substitution between ecosystem services and other input factors in production;
- We use these insights on growth rates and the elasticities of substitution of ecosystem services to assess the implications for the social discount rate.

We derive growth rates of many relevant intermediate services, or indicators thereof, such as soil nutrients, soil erosion, and biodiversity. We show that growth rates are near zero or even negative. We furthermore empirically estimate the elasticities of substitution between ecosystem services such as pollination, soil fertility and pest control, and other input factors, and find that the elasticities

of substitutions are in general less than one, which implies the limited substitutability of ecosystem services in production. These two findings imply that we need to use a time-declining discount rate towards the long-run steady state value of the social discount rate , which is the pure rate of time preference if ecosystem services do not grow, or even negative if the growth rate of ecosystem services is negative and its absolute value is sufficiently high. We also find that most of the available data on ecosystem services are crude approximations of the relevant ecosystem services that are used in production, and we discuss and propose an agenda for future research aimed at obtaining the necessary relevant data and insights.

References

Baumgärtner S, Klein AM, Thiel D, Winkler K (2015). Ramsey Discounting of Ecosystem Services. *Environmental and Resource Economics* **61**, 273-296.

Gollier C (2002). Discounting an uncertain future. *Journal of Public Economics* **85**, 149-166.

Groom B, Hepburn C (2017). Looking back at social discounting policy: the influence of papers, presentations, political preconditions, and personalities. *Review of Environmental Economics and Policy* **11**, 336-356.

Hoel M, Sterner T (2007). Discounting and relative prices. *Climate Change* **84**, 265-280.

Koetse MJ, Renes G, Ruijs A, De Zeeuw AJ (2018). *Relative Price Increase for Nature and Ecosystem Services in Cost-Benefit Analysis*. PBL Netherlands Environmental Assessment Agency, Den Haag: publication number 3214.

Traeger CP (2011). Sustainability, limited substitutability, and non-constant social discount rates. *Journal of Environmental Economics and Management* **62**, 215-228.

Weikard H-P, Zhu X (2005). Discounting and environmental quality: when should dual rates be used? *Economic Modelling* **22**, 868-878.

Zhu X, Smulders S, de Zeeuw A (2019). Discounting in the Presence of Scarce Ecosystem Services. *CESifo Working Paper*, No. 7514.