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EDITORIAL

Some comments on rotation modeling

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In a ranking of forest economics topics, optimal rotation would probably win the top position. An article by Helmedag[1] about this problem triggered various reactions. The critique is reflected in two papers published in this issue together with the response by Helmedag.

On one hand, a lively academic discussion is certainly appreciated by the scientific community. On the other hand, many forest economists judge the facets addressed by Helmedag as exhaustively discussed. One respected colleague rejected a review, commenting that this discussion is "out of time". Many editors would have rejected the publication of Helmedag's paper in the first place, sharing this opinion and being aware of the outlier position of Helmedag. This point of view is well founded and the subject editor has sympathy for this attitude, but argues on the other hand that knowledge once gained is not constantly and irreversibly acquired. It can rather fall into oblivion. It needs to be constantly taught and every generation needs to come to grips with it. From the point of view that editors should primarily care for the review of submissions, but should avoid exaggerated paternalism of authors, the paper by Helmedag was accepted. As expected, it met with criticism.

Due to the conflicting points of view, a statement of the editor seems legitimate and pursues two goals. First, it should be clarified that divergences of model-based recommendations for rotation periods are solely the result of different model assumptions. Hence, the discussion is also made more accessible to readers who are not familiar with the argumentation of forest economists. Secondly, the central question in advising forest owners needs to be addressed: Which model assumptions are suitable in different real world situations? Decision making relevance is only guaranteed as long as this question is answered and the model assumptions are accessible.

Rotation period calculations as normative models to support decision making

The question about optimal rotation is a paragon of a practical-normative case of decision making support. Forest economists can address those questions by using models from investment appraisal, which help forest owners to make better decisions. By supporting forest owners' decisions with suitable models, forest economics contributes to the well-being of the model's users. But in the case of rotation optimization, problems can arise: Being confronted with different outcomes of rotation models, the models might be judged by forest owners as useless. Users who are not familiar with the models might at best be confused. If the causes of the different rotation period result/advises are not clearly communicated, the credibility of economics as science and economists as scientists might even be at stake. Unexplained contradictions facilitate a defamation of economics and economists. In order to retain creditability, the reasons for different model outcomes (different lengths of rotation periods) should be explained very carefully.

Different assumptions lead to different results

Firstly, it is useful to recall that models mainly lead to different results based on their different assumptions. In the current case of investment-decision models, the most relevant assumptions concern the investors' objectives and the investments' financing. Unfortunately, these points remain rather untouched in some of the basic textbooks, and this also holds true for many investment-calculation models in the forest literature.

Conceptual basics of optimal rotation therefore need to be briefly addressed. To do so, we will adopt a broad

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[1] Helmedag, Fritz. (2018). From 1849 back to 1788: reconciling the Faustmann formula with the principle of maximum sustainable yield. European Journal of Forest Research. 137. https://doi.org/10.1007/s10342-018-1101-8.

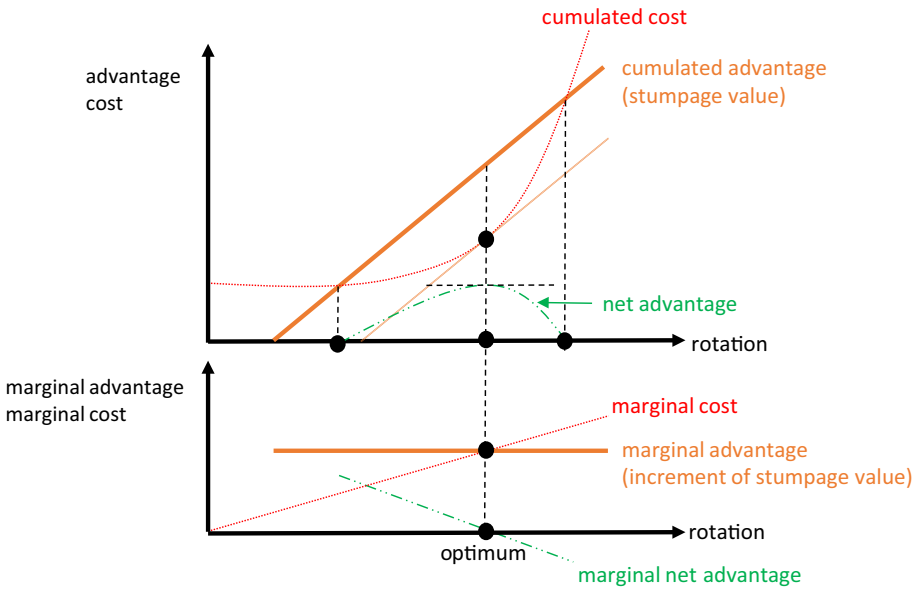

Fig. 1 General model for the optimal rotation period

definition of profit in the sense of a net advantage as a difference between advantages and costs. The optimal rotation period maximizes the net advantage under the assumption of holding the other influencing factors constant. This is done following the same procedure that is used to assess the maximum profit in relation to factor input or production quantity. In this case, the decision variable is the rotation period instead of factor input or production quantity. It is also possible to understand the rotation period as a specific production factor.

The upper part of Fig. 1 shows the cumulated advantages and the cumulated costs. The differences of the curves are the net advantage. The optimum is found by satisfying the condition for profit maximization: marginal cost = marginal revenue. In the lower graph, the point of intersection between these curves defines the optimum. The marginal net advantage is positive to the left of this point. This implies that prolonging of harvest is profitable. The marginal advantage is negative to the right of this point. This means that it is necessary to shorten the rotation period in order to maximize profit.

In general, we accept that there is only one possible point of intersection for both curves and that the curve of marginal advantage is left of the optimum, above the curve of marginal disadvantage and on the right of it below (cf. Fig. 1).

What exactly lies behind the terms of marginal costs and marginal advantages is of minor interest for the principle of this optimization. Left of the optimum, an increase in rotation period is profitable. Right of the optimum, a decrease in rotation period is profitable.

Just a few remarks about advantages and costs. Both can be grouped in two main categories. The main categories of advantages or forest use are wood (timber, stumpage value) and non-wood products. The position and form of the curve is subject to the assumptions about forest uses. In the classic models, only the stumpage value is considered. In Fig. 1, the special case of a constant increase of value is assumed to keep things as simple as possible. The best known modified model is probably the one published by Hartman[2] 1976. He demonstrates that additional uses of old forests can even result in infinite rotation.

The main categories of cost are costs for capital and costs for using the ground. Capital and ground are scarce resources that most often may have alternative uses.

The Faustmann model incorporates both categories. An interest rate represents the opportunity cost of capital, and the fact that the first utilization of the forest temporally postpones the following utilizations expresses the opportunity costs of ground. Thus, the Faustmann model is also characterized as a ground rent/land rent model. On the other hand, there are other variants of the rotation modeling that exclude certain costs. One calculation practice that can be traced back to Johann Heinrich von Thünen[3] considers the opportunity costs of capital, but does not assume the ground as scarce resource. Another calculation approach is the forest rent model, which treats ground as scarce and implies no opportunity costs of capital.

[2] Hartman, Richard. (1976). The Harvesting Decision—When a Standing Forest Has Value. Economic Inquiry. 14. p. 52–58.

[3] Thünen, Johann H. von. (1863). Der isolirte Staat in Beziehung auf Landwirthschaft und Nationalökonomie. III. Theil. Grundsätze zur Bestimmung der Bodenrente, der vortheilhaftesten Umtriebszeit und des Werths der Holzbestände von verschiedenem Alter für Kieferwaldungen. Rostock: Leopold.

A first glance at Figure 1 shows that the optimum moves further to the right the lower the marginal costs are. Under otherwise identical assumptions, the optimal rotation period according to the Faustmann model must be shorter than the one according to the forest rent model. In general, this means that with constant (marginal) advantages, the optimal rotation period will be the longer the lower the (marginal) costs are.

This quite general context allows a conclusion concerning the present discussion. Models that lead to different rotation periods while implying the same marginal advantages must have different assumptions about marginal costs. The longer the result for the optimal rotation period is, the lower the marginal cost must have been assumed. Focusing on the curve of cumulated cost means that the optimum moves to the right the less steep the curve is assumed. An "unexpected" result can only occur when there is no clarity about the assumptions. In this case, a lack of clarity might exist: assumptions have not been made explicit, and/or possibly implicit model assumptions have been changed in the course of modeling.

The subject editor wishes that Helmedag's article would have been criticized more stringently and fundamentally, deriving from such a basis that it is actually used in the two following publications. But those aspects can now be addressed to raise attention to some specifics of rotation period calculations.

Relevance before elegance

It was stressed above that the objective and the financing structure is often neglected in forest economics publications. It is of course not possible to finally determine why the objectives and the financing are so often neglected. One can only do this at a hermeneutics level. The author's interpretation is that this is due to the pursuit of simplicity and a kind of elegance of the models. This aspiration is by no means to be condemned per se. On the contrary, it is a virtue, and one can refer to the philosopher William Ockham, whose demands for the lowest possible model complexity have become known by the term of Ockham's razor. However, the author argues that this rigor in this peculiar case is the cause of the unfortunate view of forest economists.

The pursuit of model-oriented and arithmetical simplicity and elegance, in the case of Faustmann applications, leads to calculations with a constant discount rate, accompanied by constant timber prices as well as costs. As a consequence, the model gains a high degree of elegance. The Faustmann model is ultimately traced back to the formula to calculate the present value of a periodical and eternal income. This makes it easy to understand and manageable. Nevertheless, the choice of this elegant model structure determines a financing assumption that has drastic implications on relevance. Investment theory literature describes this assumption as the "perfect capital market". In a model that is based on this assumption, all financing restrictions and liquidity issues of the investor are ruled out. The investor is able to raise money and invest in the capital market at any given time and at any amount without any transaction costs. This not only eliminates liquidity problems of the investor, but also has an effect on the assumptions of the investors' objectives. If any amount of money can be borrowed and invested without transaction costs, the distinction between the goals of asset increase and achievement of net income—the generation of income—disappears. With a maximum focus on asset increase, the withdrawals and withdrawal options are automatically maximized.

The advantage of this model assumption—of the perfect capital market—entails that the investment is treated separately from financing, and if necessary can be compared with other investments. All considerations regarding the investors' objectives and their financing restrictions become superfluous. The enormous disadvantage is that the model outcomes are only relevant to investors who are not subject to any financing restrictions. This condition can be considered to be met approximately if the observed investment project only constitutes a minor part of the investors' financial scopes. First and foremost, however, this condition should at least be approximately fulfilled for investors who can easily get financing via the capital market. Only a few investors of this kind, with the exception of countries, will be identified among forest owners. Our consideration leads to the intermediate conclusion that the Faustmann model cannot claim relevance for a large number of investors, with the exception of those with good capital market access and those in whose portfolio the forest has negligible significance. Most commonly, forestry advisors will encounter forest owners who have restricted capital market access and who are subject to financing and liquidity restrictions. These forest owners must earn or want to earn income from forest management. The desired income stream does not have to be constant over time. Since the forest is by no means the only source of income, an isolated view of the forest is not appropriate for income planning. Rather, all the essential sources and all the essential uses of income must be considered simultaneously.

From this consideration, which denies the relevance of the Faustmann model in many cases, it cannot be concluded that the competing forest rent model could claim relevance in these cases.

Optimization of the rotation period in the forest rent model differs from the Faustmann formula by maximization of an eternal and, under the assumption of the fully regulated forest situation, constant income streams. It could be concluded that the forest rent model, in contrast to the Faustmann approach, assumes income maximization of

the forest owner. One can refute this assertion by simply reformulating Faustmann's model as an eternal periodic pension into an eternal annual pension. Forest economics calls this the ground rent or land rent. The maximization of the expected value of the ground is identical to the maximization of the ground rent. It is simply another formulation of the model. Under the assumption of the perfect capital market, as demonstrated above, the investor's objective (asset maximization, maximization of withdrawals) does not play a role.

Investment calculations of complete financial plans are the appropriate method to consider financing and liquidity restrictions as well as other sources of income. This goes hand in hand with a high effort to determine the data. Moreover, the planning horizon is regularly limited in time and the computational effort is high. Forest owners will rarely accept the heavy burden of such simultaneous financial and investment planning. From the scientists' point of view, a significant disadvantage is that the suitability for publication is rather low. These points can be considered as the reasons for why only a few contributions to forest management can be found in the literature regarding financing restrictions and income withdrawal targets.

The scarcity of capital differentiates between ground rent models and forest rent models

The difference in rotation periods between the Faustmann model and the forest rent model are solely dependent on different interest rates. The lower the interest rate within the model, the longer the optimal rotation period. In the limiting case, the rate of return is set to zero. Capital is then not treated as scarce. With this, competing and more profitable uses of capital are ignored. In the special case of zero interest rates, the results of the Faustmann model correspond to the forest rent model. Assuming in addition that the timber price is a constant not depending on rotation, the model results in the maximization of physical timber production (maximum sustained yield), which corresponds exactly to the result in Helmedag's contribution. Especially in German-speaking countries, forest rent models have a long tradition in forestry science. These models are characterized by computational simplicity, and the impression is created that they could claim general validity for themselves. The additional assumption of an age structure corresponding to the fully regulated forest leads to a steady stream of income from the forest. Subsequently, it is often claimed that this is the optimal situation for the forest owner. This path of reasoning is also followed by Helmedag's modeling.

The question of whether these forest rent models can claim relevance, however, must be denied vehemently. The relevance of these models is even significantly lower compared with the Faustmann models. The Faustmann approach has in common with the forest rent approach that liquidity restrictions and financing restrictions are not taken into account. Additionally, the forest rent approach entails the assumption that there are no opportunity costs of the employed capital. In other words, the scarcity of capital is not considered at all. It is not helpful for the forest owner to show him or her how to build up timber stock with a fixed forest area and by excluding alternative investments so that he or she can have a maximum and constant (over time) income stream from timber use. It is obvious that alternative investments would generate a higher income stream. While the Faustmann approach may still claim relevance to investors who have capital market access, it will be difficult to find an investor in this world who has no opportunity cost of capital.

Does the conversion to a fully regulated forest have relevance?

The need to address liquidity requirement has of course also been noticed in forestry. However, since forestry writers have regularly limited themselves to looking at forests as a source of income and investment only, they have not dealt with the alternatives to forest. It has rather been natural for forestry authors to consider the forest structure as a variable. The obvious idea is to ensure liquidity by allowing continuous use from harvesting. If the forest has the structure of a fully regulated forest, liquidity is secured. From this point of view, it is often concluded that the forest owner should seek a fully regulated forest structure of his forest. He/she should rebuild the forest, which has a different age distribution from a fully regulated forest, so that it adopts a balanced age distribution. Does this claim hold true?

First and foremost, the conversion is obviously not free of cost. The inability to harvest the forest stands at the most favorable time entails costs. For forest owners who are not subject to any liquidity requirement, the acceptance of conversion costs is irrational. They have no financial benefit from a fully regulated forest structure of their forest. We do not want to contemplate other technical advantages here. For other forest owners, the liquidity requirement also applies during a conversion phase. This complicates forest conversion. For forest owners who possess other sources of income in addition to the forest, the question arises whether measures outside of the forest can secure liquidity at lower costs. These considerations make us doubt whether there are many cases in which the recommendation to transform a forest into a fully regulated forest structure can be considered relevant.

Two situations: conversion and construction

Modeling a conversion includes the assumption that the investor already has a forest. Basically, the conversion problem is equivalent to the question of when one existing investment should be replaced by another. In contrast, there is the situation in which one starts from scratch. It is assumed in these situations that the investor would build the forest first. Those working with such models may be advised to clearly highlight this aspect of modeling as well. Both cases, the conversion situation and the construction situation, are practically occurring at the same time. However, the aspects of financing and liquidity are probably of high importance in all cases. Dynamic modeling of forest conversions with the aim of a fully regulated forest is an academic challenge and may result in interesting insights to be used in forest management. However, fundamental concerns can be raised against proposed calculations. Firstly, it should be pointed out that the uniformity of the income stream from forest management, which is assumed to be the goal, is only reasonable if the forest is considered to be isolated. This was already discussed above. Secondly, against some modeling it can be argued that this is somewhat contradictory or even paradoxical: On the one hand, the assumption of a constant income stream over time is an objective that is only economically useful for a forest owner without capital market access, and on the other hand, the modeling of the transition assumes a perfect capital market.

Conclusions

The forest economic contributions to optimize the rotation period should not be criticized in detail here. The different assumptions about objectives and restrictions can be attributed to different results. It is perfectly legitimate to make different assumptions, which should, however, be presented as transparent as possible. Criticism is necessary because of the responsibility to the users of the models and, with increasing importance in recent times, also serves the protection of science from contempt by third parties. It should therefore be noted that all models that should or can be used to support decisions need to be reviewed and assessed in stages. The absence of clear mistakes and misunderstandings is assumed. The theoretical examination asks for the transparent presentation of the assumptions and their consistency. Models with internal contradictions do not meet the scientific quality standard (rigor). The second step asks whether the assumptions correspond to real conditions in sufficient approximation (relevance). Alternatively, one can try to clarify which real situations the assumptions are sufficiently close to, or which of the situations the decision makers do not match well enough to be used as an aid to decision support. With regard to further discussion of rotation period models, the authors (and readers) are advised to pay more attention to relevance, especially under the considerations of capital market access first and foremost, and thus financing and liquidity restrictions, and also alternative investments and other assets or other sources of income.