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Economic balancing of forest management under storm risk, the case of the Ore Mountains (Germany)

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ABSTRACT

Storm events shorten the optimal rotation compared with the classical Faustmann solution.

When the neighbourhood-protection-effect changes simultaneously with site productivity and site-related arrival rates, analyses in such complex environments involve numerous, qualitatively ambiguous effects that ask for empirical escorts. We use empirical material from the Ore Mountains (Germany), where storm damages were analysed between 1831 and 1981. The calculated results show the complex interweavements of the different factors concerning storm risk. The multiple effects under storm risk ask for specific forest management strategies, which cannot be found intuitively: more complex analyses need support of economic calculations.

Problem

Storms affect the traditionally practiced even-aged Norway spruce (*Picea abies*) management in central Europe significantly. The aim of our study is to find out how much storms affect the optimal

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rotation length and the profitability of Norway spruce management when various, empirically relevant factors change simultaneously. In the centre of this study are numerical calculations of the classical land expectation values (LEV) according to Faustmann (1849) and of the expected land expectation values [E(LEV)] for varying external factors.

Studies on storm risk play an important role in forestry science in general and in the economics of forest management in particular over many decades. In every country of Central Europe, the body of literature is full of empirical studies and deductive analyses.

Amacher et al. (2009: 270 ff.) summarise the Faustmann analyses of catastrophic events based on the Reed model (Reed, 1984) for both stand age-independent and -dependent arrival rates. They find shorter optimal rotations under catastrophic events than without considering catastrophic events. Moreover, they find shorter optimal rotations in case of stand age-dependent arrival rates than in case of stand age-independent arrival rates.

Other researchers extend these fundamental analyses.

Lohmander (1987) deals with the neighbourhood-protection-effect (NPE) in the presence of storm risk. The NPE means that the survival probabilities are dependent on the height of the neighbouring stands (Lohmander, 1987: 9). Lohmander (1987: 9ff.) gives also an outline description of how forest stands affect the storm-affected survival probabilities of the neighbouring stands. This effect played an extraordinary role in the classical even-aged forest management in central Europe (e.g. Kurth, 1994: 112 ff.). New experiments in wind tunnels show details of how forest stands affect the neighbouring stands (Frank and Ruck, 2009).

Lohmander (1987) finds that the neighbourhood-protection-effect (NPE) in the presence of storm risk changes the optimal rotation length in comparison to the normal Faustmann model in an ambiguous direction. The reason is the opposite effect of the age-dependent storm survival probabilities and the NPE. While the storm survival probabilities lead to shorter rotation lengths, the NPE leads to longer rotation lengths. Qualitatively, the combined effect is thus ambiguous.

Loisel (2011) found out that for cases in which the stumpage is salvageable the optimal rotation is close to the optimal rotation without a catastrophic event. In the 2014 paper, Loisel extends his storm risk model by incorporating thinning income and price depreciations after storm events (Loisel, 2014). Staupendahl and Möhring (2011) distinguish between early and late risk, and show that the optimal rotation length shifts in different directions. While early risk lengthen the optimal rotation age, late risk shorten the optimal rotation age.

The forest site is another empirically important factor for the forest management under storm risk which, however, has received less attention in previous studies on storm risk: normally, arrival probabilities also depend on the site. However, at different sites, we observe different forest productivities, too, as every forest expert knows. As a result, storm arrival probabilities and forest productivities change simultaneously under different site conditions.

In some cases, we observe that site productivity increases together with decreasing survival probabilities. That means we exchange higher productivity for a higher storm risk. In other cases, site productivity and survival probabilities increase together. For this combination, sites with higher survival probabilities lead to fewer destructive events, but every event generates a larger amount of damage. And oppositely, sites with low survival probabilities lead to frequently destructive events, but every event generates a lower amount of damage. It follows that the combined site effect can shorten or lengthen the optimal rotation length, and can increase or decrease the profitability of the forest stand.

These cases demonstrate that the management of Norway spruce stands under storm risk involves numerous, qualitatively ambiguous effects and, thus, asks for empirical escorts of the analytical results.

We found enough data materials to investigate two types of combined effects. These are the neighbourhood-protection-effect (NPE) among different forest stands in combination with simultaneous changes of site productivity and of site-related arrival rates. For that, we apply the Faustmann model (Faustmann, 1849) as a calculation sheet for balanced appraisals when the different factors change simultaneously (cp. Price and Willis, 2011).

In this paper, we mainly employed the empirical data material by Dittrich (1985). He analysed the harvest statistics of the Saxony State Forest Administration between 1831 and 1981 in detail for the Ore Mountains and other places in Saxony in a voluminous research report of about 700 pages. Such