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Faustmann formula before Faustmann in German territorial states

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ABSTRACT

A common perception in forest and natural resource economics is that the celebrated 'Faustmann formula' was discovered in 1849 and that the 'Faustmann rule' or Faustmann–Pressler solution to the optimal forest rotation age was derived from it a decade later by Max Robert Pressler. This paper shows that the modern perspective to the valuation of forests was presented in German territorial states much earlier than has previously been thought. In 1805 a competent forest mathematician Johann Hossfeld showed explicitly how forest value can be derived under both intermittent and sustained yield management, thus discovering the Faustmann formula. The study also shows that the close intellectual and professional connections among the first German 'forest economists' seem to have played a key role in the diffusion of modern forest economic principles from Hossfeld and his contemporaries to Faustmann and Pressler, and perhaps even more generally to modern capital theory.

1. Introduction

A common notion in forest and natural resource economics is that the celebrated 'Faustmann formula' was discovered by a young Hessian forester Martin Faustmann in 1849 and that the 'Faustmann rule' or Faustmann–Pressler solution to the optimal rotation age was derived from it a decade later by a distinguished professor of forest mathematics Max Robert Pressler (e.g. Gane 1968, Samuelson 1976, Johansson and Löfgren 1985, Hanley et al. 1997, Crocker 1999). Similar perception appears also in reviews on the development of general economics (e.g. Faulhaber and Baumol 1988).

Recent research has significantly extended this understanding by showing that the economic ideas behind these innovations were presented already in the late seventeenth century England during so-called financial revolution (Viitala 2013). In his remarkable writings in 1683 and 1701, John Houghton, a London-based editor, businessman and fellow of the newly-formed Royal Society, explicitly recognized the opportunity cost of forest capital (standing timber and bare land) and compared forestry with other forms of land use employing calculations that are in line with modern capital and investment theory. While presenting these economic comparisons, he also came very close to expounding the underlying principle of the 'Faustmann rule' or 'Faustmann condition', which states that it is optimal to harvest a forest when its marginal value growth decreases under the marginal cost of forest capital consisting of standing timber plus bare land. In 1730, a competent land surveyor and accountant John Richards from Essex contributed to this line of modern forest economic thought by calculating forest value under both intermittent and sustained yield management using discounted cash flow to infinity, and thus discovering the 'Faustmann formula' more than a hundred years before Faustmann (Scorgie 1996, Viitala 2013).

The above findings are of particular interest considering that in natural resource economics literature Faustmann's contribution has been referred as 'remarkable' (Samuelson 1976, 469, 472) and Pressler has been regarded to anticipate marginal analysis (Crocker 1999, 33). Extending this line of argumentation somewhat further it has been claimed that Faustmann and Pressler produced capital theory that outplayed and was developed even earlier than its cousins within the economic discipline (Löfgren 2012). This argument finds some implicit support in Irving Fisher's famous *The Nature of Capital and Income* (1906) in which Fisher presents the idea that the value of a capital at any instant should be derived from the value of the future income which the capital is expected to yield. His celebrated book includes a brief but curious comment that such appraisement of young forests is already worked out with considerable precision in Germany and some other countries.[1]

The significance of the Faustmann formula and condition is not restricted to forestry. As pointed out by Gaffney (2008), the Faustmann

[1] "The fundamental principle which applies here is that the value of capital at any instant is derived from the value of the future income which that capital is expected to yield. Other classical examples [of this principle] are wine, the value of which is the present worth of what it will be when 'mellow' and ready for consumption; and young forests, which are worth the discounted value of the lumber they will ultimately form. In Germany and in other countries, such appraisement of forests is now worked out with considerable precision." (Fisher 1906, 188, 205)

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formula ostensibly deals with timber growth but can be adapted to deal with *all* capital assets, with any time-patterns of inputs and outputs whatsoever. Another relevant point is that although the economic problem of handling natural resources is as old as civilization (e.g. Lowry 1965), the Faustmann model (encompassing both the formula and the condition) has been regarded as perhaps the oldest *formal description* of natural resource use that is still considered to be theoretically valid (e.g. Tahvonen and Salo 1999). It appears that in early natural resource economics only the works of Johann Heinrich von Thünen (1966, 1850, 1863) contain similar theoretical sophistication with regard to capital valuation and marginal analysis as the writings of Faustmann, Pressler and other early German forest economists.

To fully acknowledge the potential merits of the early German agriculturalists and foresters in anticipating some fundamental aspects of modern resource economics it is useful to note that in the history of economics Thünen has been regarded as the first to use the calculus as a form of economic reasoning (Schumpeter 1954, 441). Blaug (1968, 321) goes a step further by asserting that Thünen's rudimentary development of the concept of marginal productivity, applied to wages as well as to the revenue of capital, his use of differential calculus and marginal reasoning to provide equilibrium solutions of economic variables make him the first truly modern economist.

The potential role of forestry in the formation of modern resource economics calls for a more extensive analysis of the early development of forest economic thinking. One of the most interesting questions is whether it is plausible that the fundamental principles related to forest valuation, opportunity cost of forest capital and optimal forest rotation age were introduced in Central Europe only approximately 150 years after they had been discovered in England. Since Faustmann and Pressler did not refer to Houghton, Richards or other English scholars, seeking an answer to this question requires that one examines in more detail the evolution of forest economic thought in German territorial states before Faustmann and Pressler. This examination is of wider interest because the origins of many long-standing controversies in forest management and planning, typically related to the role of opportunity cost of forest capital, can be traced back to this particular period.

Previous studies have examined the development of the fundamental forest economic principles almost exclusively within the space of some decades *after* Faustmann and Pressler. Löfgren (1983, 1990, 1993, 1995, 2002) and Löfgren and Mattsson (1995) have provided interesting information on the Swedish contributions and development, while Helles and Linddal (1997) have explored early Danish insights to forest economics. One of the most interesting findings has been that a Danish count Christian Reventlow made calculations on the optimal rotation age of oak and beech with a marginal approach already in the 1810s, yet without accounting for the opportunity cost of bare land. Considering that Danish forestry had close connections with the German discipline, one may ponder whether the economic ideas Reventlow promoted had been presented earlier in the German forestry literature.[2]

Other studies have examined the contribution of Faustmann and Pressler in detail. Viitala (2006) analyzed Faustmann's less-known article, published three months before his classical one, and concluded that his economic thinking was remarkably modern, and that the young forester made an impressive number of valid observations related to efficient land use and forest management already in this pioneering article (Faustmann 1849). Gong and Löfgren (2010) focused on the question whether Pressler fully understood the economic implication of the celebrated indicator percent (*Weiserprozent*), and concluded that his treatment of the rotation problem was not always economically fully consistent.

Previous studies also have elaborated the contribution of the famous German agriculturist Johann von Thünen, often referred as the founder of the location theory. In the forest and natural resource economics literature he is usually designated as belonging to the group of famous economists who have posed an unwarranted solution to the optimal forest rotation problem – others include e.g. Jevons, Heckscher, Fisher and Boulding (see, e.g. Samuelson 1976) – whereas in general economics he is typically acknowledged for his contribution on the theory of rent and resource allocation based on the principle of marginal productivity (e.g. Ekelund and Hébert 2007, 292, 401–407).

In the first volume of his influential book *Isolated State*, published in 1826 and treating forestry very briefly, Thünen (1966, 121) indeed proposed the unwarranted solution that accounted only for a single forest rotation and thus ignored the opportunity cost of bare land. However, less commonly acknowledged is the fact that in the third and last volume of the same book – published posthumously in 1863 (Thünen died in 1850) and dedicated solely to forestry – he maximized land rent and calculated optimal forest rotation of a normal forest (Manz 1986), yet erred in evaluating immature forest stands at their immediate sale value. As it happens, it was around at the same time when Faustmann wrote his celebrated article as a response to a teacher of mathematics, Edmund von Gehren (1849), who also had misspecified the value of young forest stands in his article in the preceding issue of the same forestry journal, *Allgemeine Forst- und Jagd-Zeitung*.

The above studies indicate that some conscious scholars, such as Reventlow and Thünen, both estate owners and keen experimenters in forestry, were aware of the capital nature of standing timber and its opportunity cost several decades before Faustmann who started his forestry studies only in 1841. It seems quite evident that they preceded Faustmann and Pressler also in attempts to apply marginal analysis to the optimal rotation problem. Similar line of discussion on Faustmann's precursors can be found for example in Heyer (1871), Schwappach (1888), and Gane (1968), who suggest that Faustmann and Pressler probably benefited from the insights and formulations put forward by early German forest economists like Gottlob König (1813, 1835, 1842), Wilhelm Pfeil (1823) and Johann Hundeshagen (1826).

Increased information about various further specifications of the Faustmann formula seems to have led to some confusion and apparently contradictory claims regarding its origins in the forest and natural resource economics literature. The idea of calculating forest value under both intermittent and sustained yield management using discounted cash flow to infinity has been referred for example as the Faustmann, König–Faustmann, Faustmann–Pressler, Faustmann–Wicksell, Faustmann–Pressler–Ohlin, and Faustmann–Ohlin–Preinrich–Bellman–Samuelson formula (see, e.g. Samuelson 1976, Johansson and Löfgren 1985). Similar type of obscurity seems to persist with regard to the correct solution of the optimal forest rotation problem, which has been designated e.g. as the Faustmann, Faustmann–Pressler, and Faustmann–Ohlin rule or condition.

This study contributes to the current literature by showing that a modern perspective to the valuation of forests was presented in the German territorial states almost 50 years before Faustmann by Julius Nördlinger and Johann Hossfeld, perhaps the first 'forest economists' who were accustomed to use algebraic notation in their argumentation. Nördlinger proposed that net income from the forest should be considered as an interest on forest capital, and that the value of a forest should be calculated based on the 'expected future utility' it provides, i.e. on the income it yields over an infinite series of years. Hossfeld's contribution was even more remarkable in the sense that he showed explicitly how forest value can be derived under both intermittent and sustained yield management and how young forests should be appraised accordingly. In this respect he fully captured the capital nature of forests, an idea that would resurface in Faustmann's, Presser's and Fisher's classical

[2] Several leading German foresters helped to develop Danish forestry and to establish its forestry education in the mid-eighteenth century. These foresters included, for example, Johann Georg von Langen and his private student Hans Dietrich von Zanthier (e.g. Wedekind 1835, Hess 1885, Rozsnyay 1979).

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