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About the Relevance of Faustmann Calculations in Public Forests of Hesse, Germany

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Abstract

Taking the framework conditions for the management of public forests of Hesse as a starting point, the difficulties that practitioners have in deriving benefits from optimisation calculations according to Faustmann are discussed in the following.
The calculated economic parameters for the State forest of Hesse show that forestry in Hesse allows only a low internal rate of return on capital (0.1% for Scots pine up to 1.3% for Douglas fir) and that the land expectation values are, apart from Douglas fir, negative (e.g. oak, rotation period 180 years, p: 1.5%, - € 12,800/ha). Profit-making goals could be better realised by the cultivation of more productive tree species, shorter rotation periods and the choice of alternative thinning regimes.
Why are forests still being purchased in Hesse and why don't forests owners decide in favour of a more profitable management of their forests? An attempt will be made to explain this apparently economically inconsistent behaviour.
The main reasons are seen in the precedence given to motives that are not timber production orientated, the complex system of management objectives in public forests, the extremely long production times eliminating the time preference problem and the strict sustainability principle that has proven its importance in particular with regards to an extremely uncertain prognosis for the future.
The methods that have been used for investment calculations so far only supply partial optima and do not take into account the feedback effects and emergence problems that result from the transition from stand to the forestry enterprise level.
The marketing of conservation services from the forest is increasingly achieved at prices that are considerably higher than the value of the timber produced. This means that other assessment and optimisation approaches are called for. More strongly profit-orientated forest enterprises, increasingly successful demands from conservationists for "reparation" to nature, more unmanaged forests, a reduction of the timber supply in Germany, and, in the long-term, a probable increase of timber imports make it clear that there is a problem of national economic optimisation to solve.
The analysis of woodland prices shows that neither the land expectation value nor the capitalised forest rents are important decision-making criteria for forest purchasers. The often dominating non-timber-orientated purchasing motives require a more comprehensive explanatory model and justify using methods for the estimation of the market value that are not completely consistent with the dynamic investment theory.
All in all, the impression remains that the Faustmann concept has an important didactic and heuristic value for forestry practitioners in Germany, as it teaches the "art of weighing and measuring". Under the given framework conditions, however, management decisions in public forests need to be further optimised by communicative methods as defined by Habermas.

Keywords: Faustmann, multifunction, sustainability, woodland price, Hesse, Germany

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1 Introduction

The State of Hesse (total area: 21,115 km²) is a densely populated (288 inhabitants/ km²) Federal State rich in woodlands (42% forest area) with a high gross domestic product (€ 42,300/inhabitant). The proportion of public forests with a complex system of social welfare-orientated management objectives is very high (40% State forest, 35% communal forests). The close-to-nature and multifunctional managed State forest is mainly composed of oak (12%), beech (40%), Norway spruce (28%) and Scots pine (20%). Further forestry features are: a fairly balanced age structure, an average age of 80 years, a relatively high growing stock (287 m³/ha) and a natural productivity which differs according to the tree species (current increment, on average: 8.7 m³/ha/a)[1]. The average stumpage value is € 8,300/ha, the average internal rate of return on capital ranges from 0.1% (Scots pine, rotation period 120 years) to 1.3% (Douglas Fir, rotation period 100 years) and the average land expectation value (p: 1.5%) from - € 12,800/ha (oak) to + € 3,200/ha (Douglas fir).

The forest stock, after its devastation in the Middle Ages, has been re-established thanks to the intensive efforts of foresters. In accordance with Hartig's (1795) strict sustainability concept, the forest is to be handed on to future generations in a form that would enable them to draw at least as much benefits from it as does the generation living today. Numerous statutory stipulations and the manifold expectations placed by the predominantly urban population upon forests also place in part considerable constraints upon private forest owners with profit-orientated management objectives. In spite of the very low profitability of forestry, investment alternatives are used hardly at all by forest owners.

Starting out from these framework conditions, this paper discusses the difficulties faced by forestry practitioners in deriving benefits from the formally valid and most instructive optimisation calculations according to Faustmann. The dilemma revealed thereby is that the multi-dimensional influential factors require more complex calculation models than have been usual in the past, whilst on the other hand the increasing degree of complexity means that implementation of the results in practice is ever less successful. This contribution from a practitioner is intended to provide the inspiration for a practice-orientated research.

2 Data and Methods

Economic parameters for the main tree species of the State forest of Hesse were calculated as a basis for discussing the practical relevance of Faustmann calculations. Furthermore, published calculations of other authors were analysed.
The basis for the data of the calculated parameters is formed by the survey results for the State forest (medium reference year: 2002). As forest inventory in Hesse still takes place only on the basis of standard yield table estimations, the error of the results is unknown. Particularly the rate of increment and the mean diameter (DBH) is mostly underestimated. This supposition is confirmed by a number of special surveys (Federal Forest Inventory, sample plot surveys). As the DBH has a crucial effect upon the assortment distribution and the timber price, the DBH data of the yield tables were calibrated by means of a regression function derived from the data of the Federal Forest Inventory (BWI II) before the economic parameters were calculated. A calibration of the increment rates is to follow in the same way. For the value calculation an average level of the timber price (2005-2007, whereby the

[1] All m³ figures in this paper refer to m³ with bark to 7 cm top diameter.

year 2007 was double-weighted), the HESSEN-FORST stand assortment tables (Offer and Staupendahl, 2008) and for production costs mechanised harvesting and for broadleaves > 40 cm DBH motor-manual logging was assumed.

2.1 Natural productivity figures and stumpage value

Figure 1 shows the natural productivity key figures and stumpage values for the main tree species as derived from the forest survey data in a relative comparison. The tree species with the lowest current increment (oak; MAI_{max} 4,5 m³/ha/a) have in relation to the increment as well as absolutely the highest mean stumpage value (€ 11,200/ha, rotation period 180 years) as oak supplies in comparison to other tree species the highest proportion of valuable sawlog timber.

In comparison to the area it occupies, Scots pine has comparatively and absolutely the lowest and Norway spruce, despite its highest risk of premature loss by calamities (windthrow, bark beetles), the comparatively highest stumpage value (Scots pine: € 6,200/ha, rotation period 120 years and Norway spruce: € 9,900/ha, rotation period 100 years). Both tree species produce mainly mass products and few quality timber.

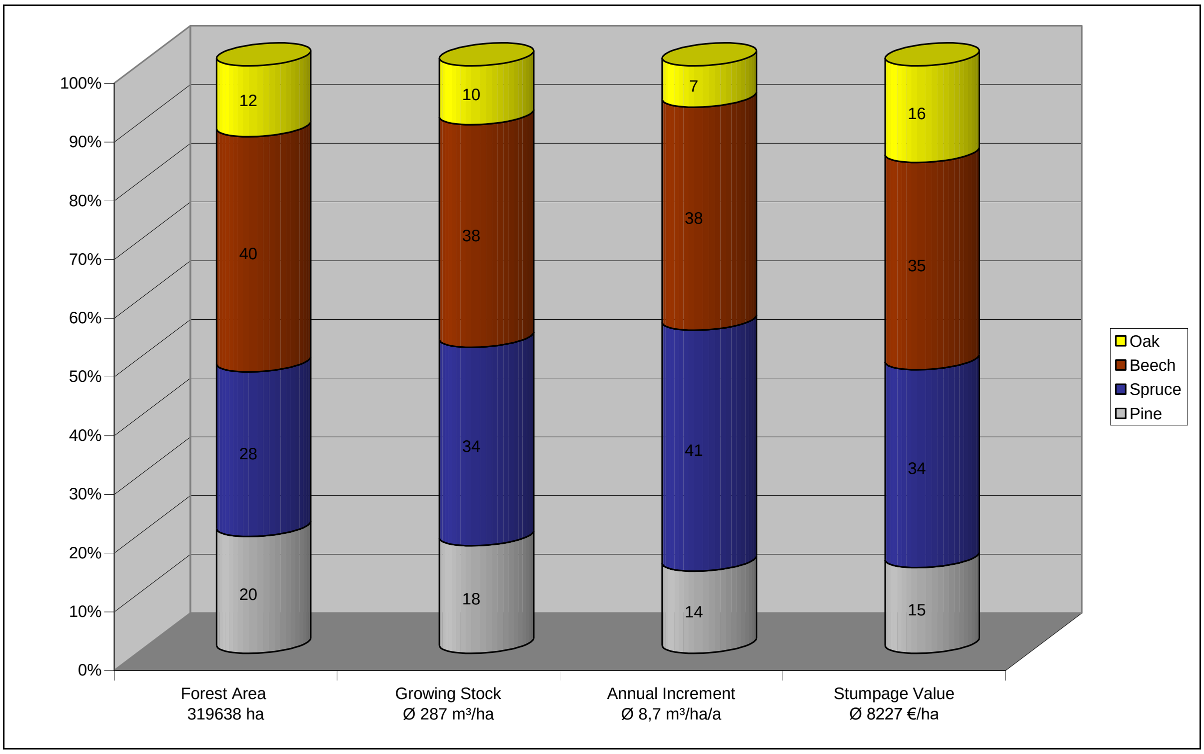

Fig.1: *Natural productivity figures and stumpage value of the main tree species in the State forest of Hesse in a relative comparison.*

2.2 Internal rate of return on capital

The calculation of the internal rate of return on capital was done by means of the static basic equation (conversion of the Faustmann formula) by iteration. Equation (1) was used for this purpose.

$$A_U + \left(\sum D_a * 1{,}0p^{U-a}\right) = c * 1{,}0p^U + (B+V)\left(1{,}0p^U - 1\right) \qquad (1)$$

In which

A_U: Stumpage Value for final cut
$\sum D_a$: Value of thinnings at different periods of time (a)
c: Establishment costs
B: Market Value of soil
V: Capitalised management costs
U: Rotation period
p: Internal rate of return on capital

Tree Species	Rotation Period [a]	Yield Class MAI_{max} [m³/ha/a]	Stumpage Value Final Cut [€/ha]	∑ Value of Thinnings [€/ha]	Market Value of Soil [€/ha]	Establishment Costs [€/ha]	Management Costs [€/ha/a]	Internal Rate of Return [%]
Oak	180	4,5	25856	17000	4000	8000	143	0,22
Beech	140	6,7	16623	11798	4000	2000	129	0,40
Spruce	100	10,9	23871	10433	4000	1500	150	1,02
Douglas Fir	100	13,4	29023	16523	4000	3000	160	1,34
Pine	120	7,2	11481	7079	4000	4000	133	0,09

Table 1*: Calculation data and internal rate of return on capital for the main tree species in the State forest of Hesse*

When interpreting the data in Table 1, there are fife issues to consider. First, the values stated in the table have not been compounded to the final age in order to enable a better comparison of those values. Second, the initial data refer on principle to the average values of the State Forest of Hesse, not taking risk costs into account. Ideal forest structure has been assumed. Third, the stumpage value has been calculated from the yield class at the time of the rotation age and the value of thinnings on the basis of the different yield classes due to the various age classes. Fourth, the establishment costs are the result of a mixed calculation from the average percentages of natural regeneration and planting. For example, beech regeneration results mainly (80%) in natural regeneration. Fifth, the management costs are made upon a percentage dependent on the tree species (V_{var}) and a fixed percentage of organisational costs (V_{fix}). Mainly as a result of the different management objectives, the fixed cost percentage in the State Forest is significantly higher than in communal and private forests. A tax and subsidy policy that distinguishes between different forest land owners also require a differentiating analysis and makes a direct comparison more difficult.

2.3 Land expectation value, forest rent, capitalised forest rent, market price for woodlands and return on investment

On the basis of the same initial data as had been used for the calculation of the internal rate of return, the land expectation values were calculated using the Faustmann formula, assuming a calculatory rate of interest of 1.5% and the forest rents (as a rent and capitalised at a rate of 3%) were calculated by means of the formula below (Table 2). An ideal forest structure has been assumed. Risk costs have not been taken into account. The height of the assumed capitalisation rate of interest – also known as the forestry rate of interest – is not discussed here (cf. Mantel, 1982).

$$WR = \frac{A_U + \sum D_a - (c + U * v)}{U * 0{,}0p} \qquad (2)$$

In which:

WR:	Capitalised Forest rent
A_U:	Stumpage Value of Final Cut
$\sum D_a$:	Value of thinnings at different periods of time
c:	Establishment costs
v:	Annual management costs
p:	Interest rate for capitalisation
U:	Rotation period

In addition, the average market price and the standard deviation for woodlands that are currently paid in Hesse have been listed. The data have been taken from the purchasing price statistics collected by the Hesse State Office for Land Management and Geographic Information (HLBG) for the period from 1997 to 2007 and have been evaluated by Wagner (2008). The purchasing prices (1994 cases) refer to an average size of the forest areas sold of 1.2 ha. For woodlands over 10 ha, the market price decreases to about 60% of the values named. The evaluation is connected to various uncertainties that cannot be discussed in more detail here. Undisputed, however, is the underlying trend: no great price differences between the different tree species and a very high standard deviation. The return on investment has been calculated as a quotient from the forest rent [€/ha/a] and the average purchasing price [market price in €/ha].

Tree species	Land Expectation Value	Forest Rent		Market Price for Woodlands		Return on Investment
			Capitalised			
	[€/ha]	[€/ha/a]	[€/ha]	[€/ha]	σ [€/ha]	[%]
Oak	-12800	51	1688	10000	+/-14000	0,5
Beech	-5200	60	1990	10000	+/-14000	0,6
Spruce	-550	173	5768	9700	+/-5900	1,8
Douglas Fir	+3200	265	8849	9700	+/-5900	2,7
Pine	-8900	-12	389	8700	+/-6900	-0,1

Table 2: *Land Expectation Value, Forest Rent, Market Price for Woodlands and Return on Investment for tree species in the State forest of Hesse*

3 Results and Discussion

3.1 Optimisation of the choice of tree species

The choice of tree species represents investment alternatives. With the Faustmann formula, it is possible to assess the alternatives financially. If the objective of a forest owner is to maximise his profit from timber production, then those tree species with a low profitability (oak, Scots pine should be replaced at the earliest opportunity by species with the highest land expectation value or forest rent (Douglas fir). Purchasers of forests should prefer those with higher return on investment and be prepared to pay a higher price for it (cf. Table 1 and 2). In German forestry enterprises of today, both of these patterns of behaviour derived from classic investment theory can only be observed to a very limited extent, as will be explained in the following.

The objective settings for public forestry enterprises prescribed by the democratic decision-making bodies are usually multi-dimensional and complex (e.g. RiBeS, 2002). They contain many non-operational restrictions. For this reason, only partial optima could be calculated so far by means of theoretical investment concepts (cf. Stang, 2008), whereas the overall optimum is to be found by iterative procedures. In this respect, other methods of operations research (e.g. benefit value analysis, AHP, DEXI, SWOT) have better proven their worth as these provide encouragement to look at an optimisation problem in a creative manner from various points of view and the results thereof can therefore be more easily communicated (Henne, 1976, Krč et.al., 2008).

For the State forest of Hesse, this results in several specifications. First, management principles are, in addition to sustainability and profitability, a forest management that will further its stability and diversity as well as its ability to adopt and develop. Second, in the long-term, the following percentages of tree species are being striven for: 12% oak, 45% beech and other deciduous species, 27% Norway spruce, 6% Douglas fir, 3% European larch and 7% Scots pine. In this way, those species with a low profitability (oak, Scots pine) will, in the interest of objectives towards public welfare, nevertheless still be permitted a large proportion of forest area. As a general rule, mixed rather than pure stands should be established in order to reduce risk of premature losses by calamities. Larger-scale clear-cuts should be the exception. Third, conservation objectives are to be given priority in about 10% of the State forest area. In these areas, forest operations should promote or establish mainly native broadleaves, particularly beech. Fourth, about 15% of the State forest is located in areas that, according to the EEC Habitats Directive, have been declared special areas of conservation (NATURA 2000 network), in which a general ban on deterioration is in force. This means, for example, that the proportion of coniferous species may not be increased in these areas. In order to avoid compensation payments to other forest owners, the fulfilment of this specification is to take place primarily in the State forest. Fifth, the best precaution to take to ensure forest conservation in times of changing environmental conditions (e.g. climate change) is to be seen in planting tree species that are as adaptable as possible, regardless of their profitability.

By means of a well-aimed subsidy policy communal and private woodland owners are also encouraged to establish close-to-nature structured forests. The various financial incentives for different measures must be taken into account when calculating the overall financial optimum.

3.2 Optimisation of the rotation period

A number of studies concern themselves with the determination of the financially optimal rotation period by means of dynamic investment calculation (e.g. Beinhofer, 2007 and 2008).

For Norway spruce, Beinhofer (2007), on the assumption of an average risk of loss, a potential crop tree thinning regime and a calculatory rate of interest of 1.5%, calculated a financially optimal rotation period of 60 years. For the variant without risk of loss and without claim of interest, he calculated an optimal rotation period of 120 years. This age corresponds more or less to the reality in public-owned forests.

Moog (1999) calls it a paradox that rotation periods and growing stock volume are even increasing in all types of forest ownership in spite of the decreasing profitability of forestry enterprises. Considerable annual losses are postulated by long rotation periods and it is recommended that as much of the capital tied up in the growing stock as possible should be released and redeployed in other, more profitable forestry investments (Moog et.al., 2001, quoted by Beinhofer, 2008, p. 129).

Rotation periods longer than the financial optimum can be declared to be rational if a multidimensional approach is adopted, instead of one-dimensional or partial explanatory models. Vehkamäki (2008a) explains the mathematical (non-linear feedback effects) and epistemological problems involved. As the models become more complex, they become less convincing for practitioners.

The preoccupation with the question as to why the financially optimal rotation period is a criterion that plays a mostly subordinate role in decision-making in German forestry enterprises illustrates the difficulties of applying decision models based on investment theory in this sector of economy:

- In industrialised countries with a long tradition in forestry, action is taken in the context of social and political conventions. What is good forestry practice and what is not is increasingly being negotiated within society. This procedure corresponds to Habermas's theory of communicative action (Erikson, 2004).
- Ethical implications arise from Hartig's strict sustainability concept (1795). Forests with a high growing stock volume that our ancestors had built up under hardship because of the manifold benefits they bring will not be reduced in their multifunctional capabilities by a relatively rich country without good cause.
- As a general rule, not single stands but sustainable structured forests are managed. Manifold feedback effects and emergence problems are incurred at the transition from the stand to the forestry enterprise level. This is why optimisation calculations for single stands, even when they take some constraints into account (e.g. Stang et.al. 2008), can only be transferred to the forestry enterprise level to a very limited extent.
- Close-to-nature forest management avoids clear-fellings. Instead, multi-story-structured forests are desired that ideally make it possible to harvest all timber assortments at the same area as well as natural regeneration instead of costly re-planting. Such forest structures are only gained by silvicultural systems with long rotation periods.
- The ecological and recreational value of a forest increases as a rule with the age of the forest. The objectives of profit maximisation and maximisation of ecological and recreational functions mutually exclude one other. Compromises (optimisation solutions) are achieved repeatedly through negotiations.

- The longer the rotation period, the greater the extent to which the time preference, i.e. the interest rate and discounting problem, loses its significance. This can be demonstrated impressively by a comparative calculation of the land expectation values for oak (rotation period: 180 years) with the interest rate variants 1.5% and 3%. For both variants, about the same land expectation value was calculated.
- The establishment costs for a stand of oak that is today 180 years old which were invested before a number of monetary reforms do not influence today's harvesting decisions. Due to the length of the prediction period, assumptions regarding the framework conditions for timber production in 100 or 200 years time are hardly possible (e.g. timber price, forest operation costs, timber demand in terms of quantity and quality). More likely is the prediction that the social functions of a forest will still be in demand then.
- Many impressive examples for a change of forestry objectives are known from forest history. That a forest that was established to meet the demand for firewood or to supply acorns for pig-fattening is no longer available for this purpose as a result of being declared a natural forest reserve is a development that our ancestors were unable to predict.
- Anyone purchasing a forest in Germany today knows that he will have to content himself with a low profitability of timber production. Non timber-production related purchasing motives are frequently prevalent. This assumption is underlined by the fact that the purchasing prices of woodlands are, as a rule, considerably higher than the land expectation value or the forest rent (→ Chapter 2.3). That is why the derivation of the calculatory rate of interest from a possible investment alternative to timber production as required by investment theory is also questionable here.
- In particular in the case of small-scale privately-owned forests in rural areas, the forest fulfils an important "saving bank function". Here, timber of different size classes ("multi-aged forest structure", "Plenterwald") is stored up for possible uncertain times. Higher harvesting intensity mostly occurs only when the owner has a particularly high (financial) demand. Liquidation and reinvestment into more profitable investments is seldom an alternative taken into account by this type of forest owner. This traditional form of provision against risks has, in general, proven its worth and is also recommended by Duffner (1999) analogously for larger forestry enterprises: longer rotation periods and thereby a higher growing stock volume enable a greater degree of flexibility with regard to removals and can thus assume the function of risk protection for economic emergencies within the portfolio of a forestry enterprise (Duffner, 1999, quoted by Beinhofer, 2008, p. 129).

3.3 Optimisation of thinning models

The advantageousness of certain thinning models is constantly being controversially discussed (e.g. Spellmann, 2005). Dynamic investment calculations offer argumentation and decision making help with regard to this question. A look at the results (e.g. Beinhofer, 2007 and 2008), however, reveals some of the typical problems connected with this method of appraisal. First, the recommendations depend decisively upon the assumed interest rate: according to Beinhofer (2007), low thinning of spruce yields the highest net present value when the interest rate lies between 0% and 2% and potential-crop-tree-thinning when the assumed interest rate is higher. Second, the differences in net present values determined for different variants are so low that the slightest changes in premises (e.g. the height of the establishment costs!, assortment prices according to size class and timber quality, logging costs) or unpredictable developments (e.g. demand for narrow-ringed timber of spruce) suffices to alter the rankings. This reduces the informative value of the results. Third, important side conditions are often not taken into account, such as the influence of various thinning variants and the influence of the intensity of thinning on the stability of the stand. The number of potential crop trees/ha also influences the results.

Low differences in net present value, uncertain predictions, a high volatility in the results and contradictory recommendations (e.g. Roeder et.al. 1988) – how shall practitioners set up a sustainable forest management with production cycles of mostly more than 100 years on that sort of results? On the basis of forestry experiences gathered in the past, it is supposed that – within a certain framework – the greatest possible diversity in conduct – according to regions, sites, thinning models, the protagonists and their different preferences – should turn out to be optimal. Experienced and cautious practitioners therefore not infrequently act according to the scientifically unsatisfactory rule “Let’s do the one without neglecting the other”. A system-theoretical study by Uerpmann (2008) supports this rule of behaviour and interprets it as a characteristic feature of sustainable management.

3.4 Optimisation problems in the exploitation of alternative marketing opportunities

The liquidation of forests within the framework of the legal possibilities or a sale with the intention of reinvesting into assets yielding a higher return on investment are currently rather the expectation in German forestry.

For a long time, the conservation functions of a forest were considered to be unmarketable. In the meantime, due to altered legal framework conditions and state subsidy schemes, new sources of income are opening up for forest land owners in return for the supply of conservation services. The demand for such services has risen considerably.

For constraints imposed upon “good forestry practice”-management as a result of the declaration of protected areas or of conservation plans (e.g. for NATURA 2000 areas) a claim to financial compensation exists according to compensation laws, or – as is paramount in Hesse – on the basis of contracts between the State and the forest land owner. According to a special compensation directive of the State of Hesse (“Kompensationsverordnung”), anyone who disturbs the ecological balance of an area through construction measures (e.g. road construction) is obliged to perform a substitution or compensation measure. It is typically the following conservation services that are in demand: the reconstruction of site-adopted native woodlands, the long-term preservation of mature native woodlands until the decaying phase, the maintenance of mature native broadleaved trees.

In this respect, the question asked of the woodland owner is the price for which he should supply this service. In accordance with the marginal price concept, he should demand at least the difference to the profit that could be expected from an optimal profit-orientated forest management. By using the annuity method, Möhring et.al. (2008) have calculated standardised annual payment amounts per hectare (“annual timber production value”) that are documented in value tables. A calculatory rate of interest of 1.5% was assumed. This tool forms an important negotiation basis for a contract-based forest management and in all cases in which the forest owner is not legally entitled to claim compensation payments.

The evaluation approach of the Hesse compensation directive, on the other hand, is based upon the conservation value of the forest that is calculated as a point score according to ecological criteria. The sum of point scores is multiplied by the recommended price per point score of at present 0.35 € per m^2 of forest area. Depending on the demand for conservation services, the forest land owner can attain this amount, a higher or a lower one. The forest owners' supply exceeds the demand considerably, as they are able to achieve significantly higher revenues from the sale of conservation services than would have been possible by a profit-orientated forestry management. With the help of Möhring's value tables, it can be estimated that the market value of conservation services of a forest area in Hesse can be four to five times as high as the net present value of a stand from timber production.

This new market also appears to be having an effect upon the current market prices of forests. Whereas previously it had become known in individual cases that the market value of a forest decreases when the area is declared a NATURA 2000 area, valuation experts today are reporting that those interested in purchasing smaller forests are prepared to pay higher prices when financial subsidy or marketing possibilities for conservation services exist.

The altered situation shows that the following difficulties are incurred when applying dynamic investment calculation methods in the common way. First, the market value of a forest is, in addition to the value of timber production, increasingly determined by its ability to supply conservation services. Second, this ability is not timber-yield but growing-stock-volume-orientated. Therefore, the payment demand – as is usual in German compensation practice and has been confirmed by the courts – should at least be orientated towards the substance value of a forest (stumpage value of mature or expectation value of premature stands). The older and closer to nature a particular stand is, the higher the owner's claim for compensation should be in the case of renunciation of timber production. Third, with the annuity method, annual payment amounts are calculated within which the planting costs are offset. As a rule, however, a forest land owner is only prepared to convert a productive exotic softwood stand into a less productive native broadleaved stand when he receives a one-off payment in the year of the implementation of the measure. This payment is made up of the components losses by premature felling (= difference between stand expectation value defined by convention and the current stumpage value), the additional costs for the establishment of a more costly plantation and the capitalised forest rent difference between the softwood and the broadleaved stand (Haub, 1996). Fourth, Möhring's value tables illustrate very clearly the establishment cost problem in dynamic investment calculations. A stand of beech (MAI_{max} 7.2 m^3/ha/a) that had to be planted 140 years ago shows a timber production value of - € 19/ha/a whilst a stand established by natural regeneration (without planting costs) has a timber production value of € 67/ha/a. It would be difficult to explain to a person entitled to compensation that the amount of his claim is to depend upon the method according to which the stand was established 140 years ago.

The increased demand for conservation services to be performed by the forest also points to an unsolved and complex national economic optimisation problem (Pabst, 1991). Up until the 1980s, there was a broad consensus within society that forestry enterprises, in addition to timber production, also supplies all other forestry services in an optimal combination of functions. In the years that followed, powerful governmental and non-governmental organisations grew up that – endowed with copious staff and financial volumes – concern themselves exclusively with the enforcement of conservation matters, as well as public forestry organisations with drastically reduced staff levels, which are expected to operate at a profit. The more these are orientated towards profit-making, the greater the expectation of society that they should supply conservational services as a way of making reparations to nature. The profits made by public forest owners are marginal in comparison to the public sector expenditure in the field of conversation. It is, in particular, desired that conservationism should lead to wide scale areas being unmanaged or not managed any more with the main objective of timber production. This reduces timber supply in Germany in the long term. The timber balance, already negative, must, in the long-term, be compensated by increase of timber imports. This development can be described as unsatisfactory from a national-economic point of view.

3.5 Land expectation value and forest market value

In many countries, potential purchasers with profit-making targets determine the margin price for a parcel of land for forestry using the Faustmann formula. As Table 2 illustrates, all land expectation values calculated for the State forest of Hesse are negative (apart from those for Douglas fir). Negative land expectation values have been a typical characteristic for forest lands in Germany since the end of the Second World War (Katò, 1976). This diagnosis clearly illustrates what has been known and undisputed for a long time now, namely that – in contrast to the agricultural sector – the price for forest land is no longer, or at least only to a limited extent, influenced by the profit to be expected of a forest by timber production (e.g. Petri, 1971).

The location factor has proven the decisive factor for determining the value of the forest land (Weimann, 1983). The higher the population density, the greater the demand for the non-increasable factor land and the higher the price of this, even though forest land may not, as a rule, be converted to a higher quality type of usage (e.g. building land) for legal reasons.

In the urban area in Southern-Hesse, the average price for woodlands is roughly 7-times the value of such land in the region of Hesse with the lowest average price for woodlands (Werra-Meissner-Kreis) (Wagner, 2008).

Normally, it is not bare forest land that is bought in Germany, but woodlands that are managed in a sustainable manner. The margin price calculation made by a potential purchaser with profit-making targets for woodland in a rural area should therefore be orientated towards the capitalised forest rent. The prices actually paid for *small* woodlands in Hesse (< 5 ha) are, however, considerably higher than the capitalised forest rents that have been calculated for the State forest (Table 2). The purchase price differences for woodlands of different tree species are only relatively small, despite the fact that the capitalised forest rents for stands of different tree species differ widely. As the size of the area of woodland sold increases, the difference between purchasing price and capitalised forest rent decreases (Figure 2). However, only in the case of purely coniferous forestry enterprises (> 5 ha) does the purchasing price approximately amounts to the capitalised forest rent.

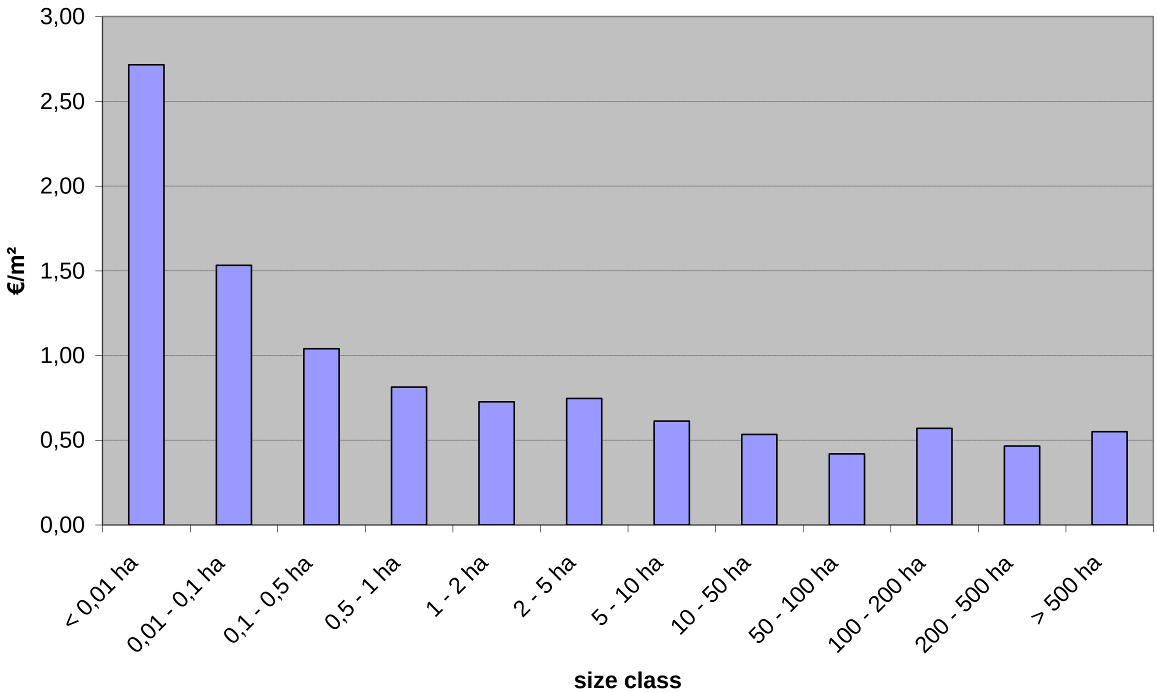

Figure 2: *Average purchasing price according to size classes for sales of woodlands in Hesse between 1997- 2007 (Source: WAGNER 2008 modified).*

These findings and the high standard deviations of the woodland prices show that the woodland price can also only be explained to a very limited extent by the profitability of a forest. From the difference between the capitalised forest rent and the woodland price one can deduce that, for small woodlands, the portion of value of non-timber related purchasing motives is between 1.5 and 20-times above the value percentage of the capitalised forest rent. For large woodlands, the value portion of the capitalised forest rent in the purchasing price increases.

The various motives for purchasing forest enterprises and the influence they have on the purchasing price have been determined in a survey carried out by Löffler (2005). The motives of purchasers of small-scaled woodlands are likely to be even more complex, as their decisions are clearly influenced to an even lesser extent by forestry value determination factors. This question is more closely examined in a research project carried out by Wagner (2008) by means of the multiple regression analysis.

A better understanding of the woodland purchasers' behavioural pattern can probably succeed by means of an investment theory explanatory model in accordance with the paradigm of Darwinism (Dunbar et. al., 2007). According to this, it is to be assumed that the behaviour of human beings is controlled by the overwhelmingly unconscious aim of maximising one's own benefit. This cost-benefit result calculates in the currency of overall fitness (breeding success), exceeds the time-scale of one's own existence (sustainability concept) and goes well beyond the profit-maximisation concept of the neo-classic economy.

Due to the high proportion of personal purchasing preferences, the market value of woodlands in Germany is very difficult to estimate. With regard to *compensation cases*, the estimation of the market value is codified in a federal directive (WaldR 2000). According to this, the market value is a tangible asset-orientated value defined by convention that is made up of the partial values for the forest land and for the growing stock. The growing stock value (calculated by BLUME formula) is –to oversimplify matters somewhat – calculated from an age-dependant interpolation between the two fixed points, standardised planting costs and stumpage value, whereby the interpolation factor (age-value factor) expresses the stock value as a relative number to the stumpage value (Haub et.al., 2000). The criticism has been raised that this method is not consistent from an investment theory point of view and that the BLUME stock value does not correspond to any of the value concepts used thus far in assessment theory (e.g. Moog, 1990 and Sekot, 2007).

The estimation of the market value of woodlands when selling on the *free property market* is undertaken by valuation experts using pragmatic methods (Offer, 2009). Due to the high proportion of factors influencing the purchasing price that can not be grasped in economic terms, the demand made upon the assessment methods should not be as strict as usual. Measuring criteria for their suitability should be the market reference of this estimate, the acceptance thereof and its contribution to keeping peace under the law.

4 Conclusion

The natural and economic parameters that have been determined reveal that, in comparison with possible investment alternatives, only a very low return on invested capital is possible. Profit-orientated objectives can be better achieved by the establishment of more profitable tree species, a reduction of the rotation period and the selection of alternative thinning models. An attempt has been made here to explain why, despite all of this, woodlands are still being bought and why the tools for decision-making provided by the Faustmann concept are so little used in practice.

The main reasons are to be seen in the precedence of non-timber production related purchasing motives, the complex system of target setting in public forests, the very long production times whilst dissolving the question of time preference and the strict sustainability principle that has proven its importance in particular with regards to an extremely uncertain prognosis for the future.

The methods so far used for investment calculations only supply partial optima and do not take into account the feedback effects and emergence problems that result from the transition from the stand to the forestry enterprise level. Other methods of operations research offer tools that do better justice to every day practice (e.g. benefit value analysis, SWOT analysis). The marketing of conservation services from forests is increasingly achieved at prices that are considerably higher than the value of the timber produced. This means that other approaches to assessment and optimisation are called for.

The analysis of woodland prices shows that neither the land expectation value nor the capitalised forest rents are important decision-making criteria for forest purchasers. The often dominating, non timber-production related purchasing motives require a more comprehensive explanatory model and justify using methods to estimate the market value that are not completely consistent with the dynamic investment theory.

All in all, we are left with Vehkamäki’s (2008b) estimation that the Faustmann concept has an important didactic and heuristic value for forestry practitioners in Germany as it teaches the “art of weighing and measuring”. Under the given framework conditions, however, management decisions in public forests need to be further optimised by communicative methods as taught by Habermas..

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