Simultaneous optimization of rotation periods and tree species composition

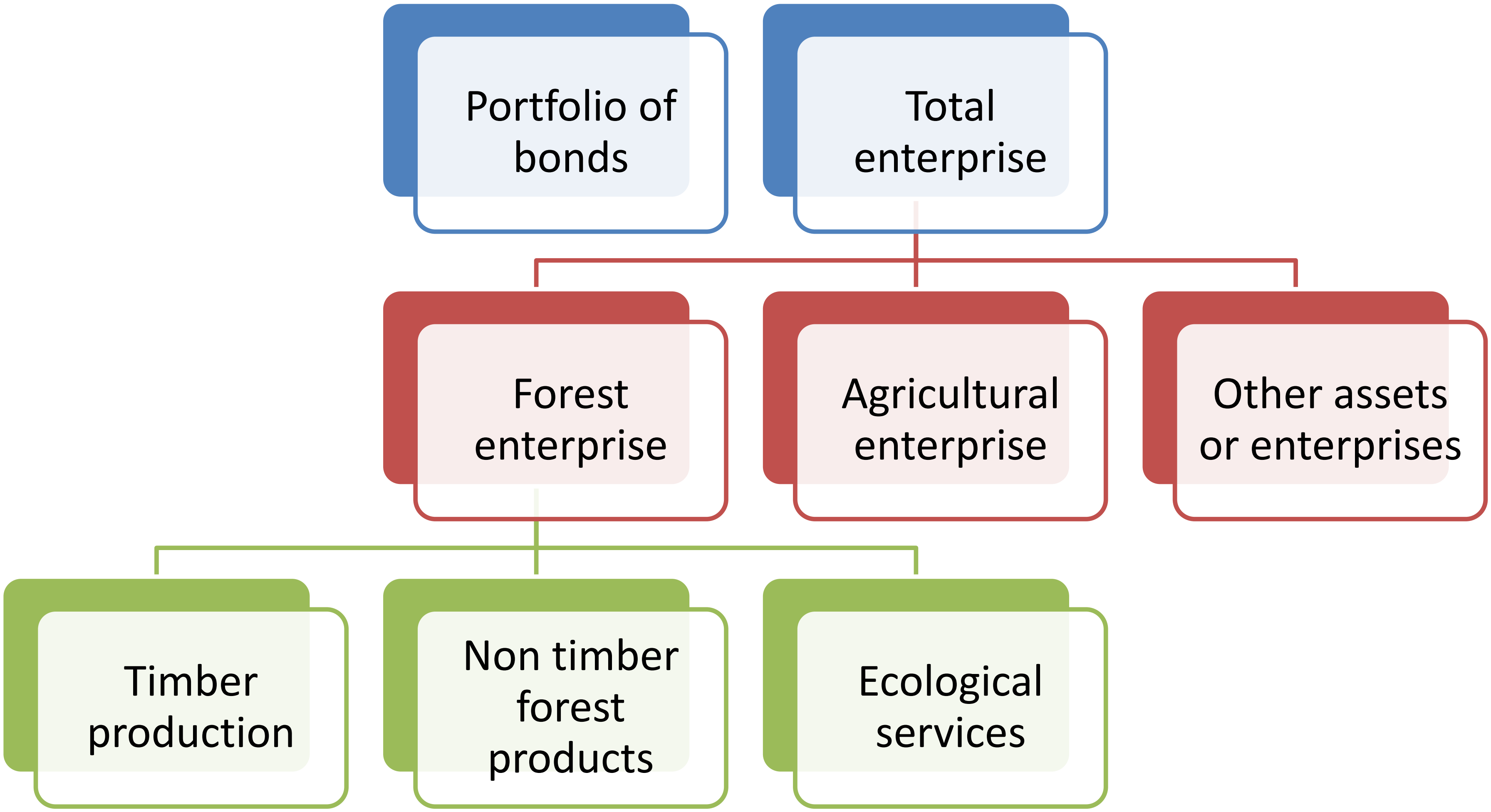
IFM
Institute of Forest Management

Jörg Rößiger

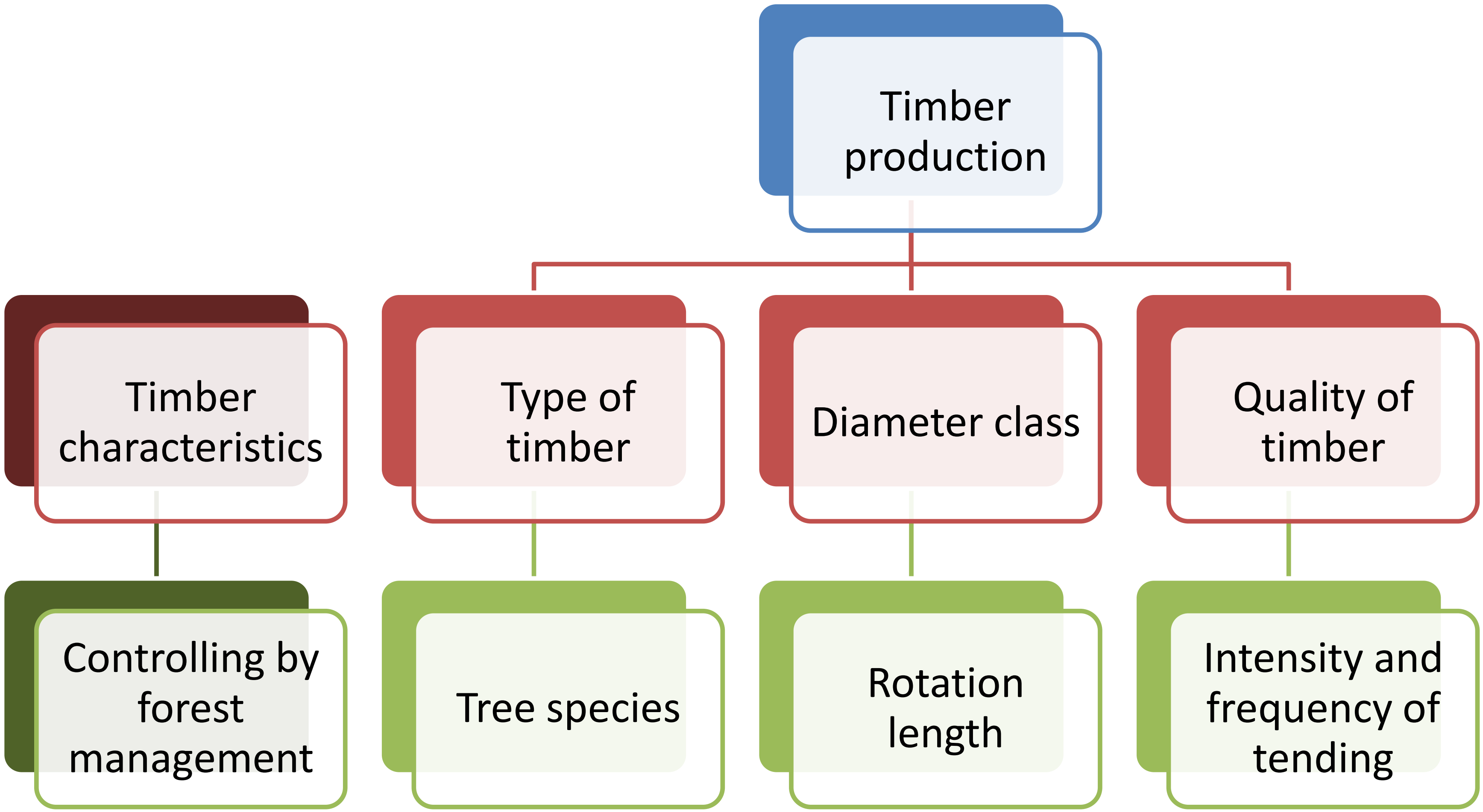
Question of optimization

- All management decisions in forestry include risks
- Determination of these risks and consider them for planning
- Aim of financial optimization of a forest enterprise is
  - to maximize the expected income or
  - to minimize the risk by diversification
  - by advising the best management decisions

The diversification effect of forestry

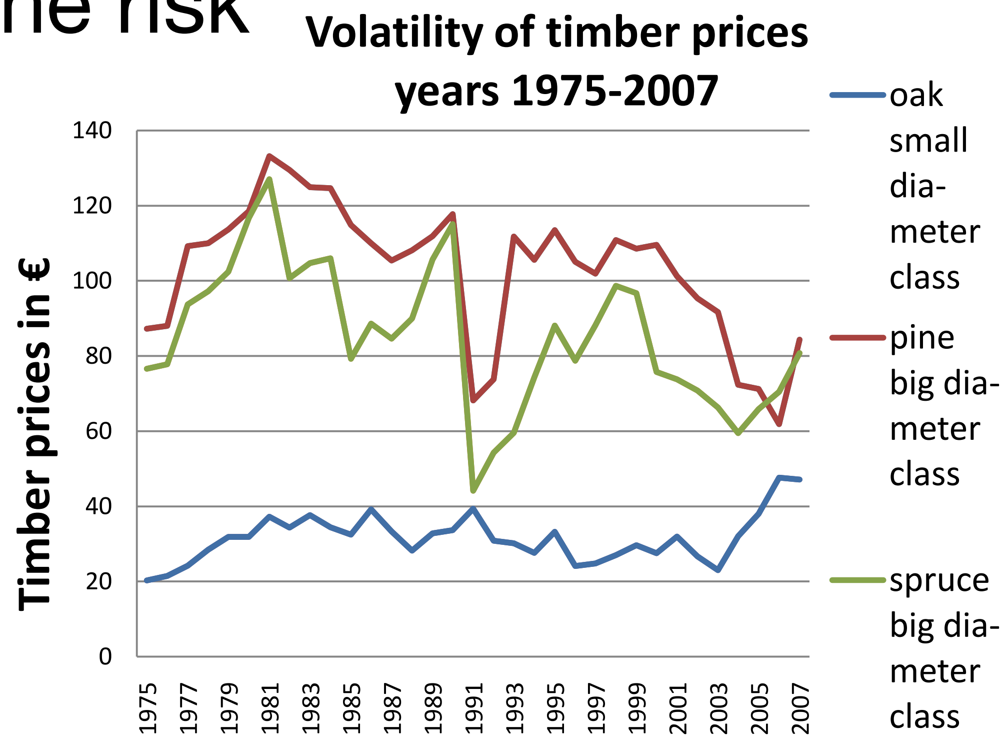


Diversification in timber production



Determination of the risk of a compostion of timber grades according to Markowitz

- Correlation coefficients of the timber price statistic describe the risk
- Correlation coefficients:
  - – pine:spruce +0.80
  - – oak :spruce +0.05
  - – oak :pine - 0.07



Return of a portfolio: Markowitz 1952

$$E_{Po} = \sum_{i=1}^{N} a_i \times E_i \qquad \sum_{i=1}^{N} a_i = 1$$

- E_{Po} expected value of a portfolio
- E_i expected value of investment i
- a_i fraction of investment i of the total portfolio
- N number of investments (a_i to a_N)

Standard deviation of portfolio return Markowitz 1952

$$s_{Po} = \sqrt{\sum_{i \in Po} a_i^2 \times s_i^2 + 2 \times \sum_{i \in Po} \sum_{j \in Po; j > i} a_i \times a_j \times s_i \times s_j \times k_{ij}}$$

- s_{Po} standard deviation of portfolio return
- s_i standard deviation of portfolio component i
- k_{ij} correlation coefficient of return between the portfolio components i and j

Example data:

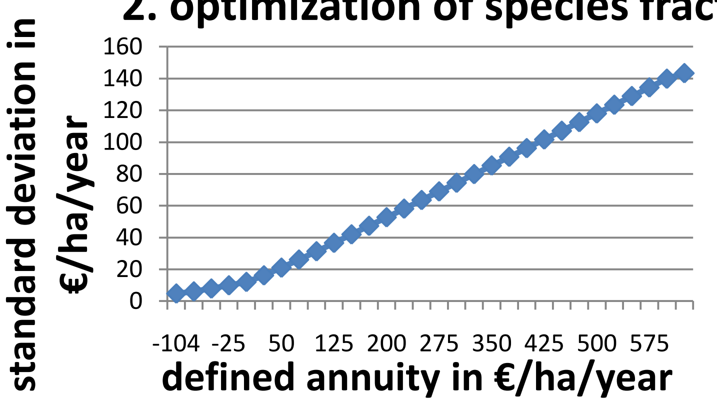
	s	a
oak small	6	0.3
pine big	18	0.2
spruce big	19	0.5

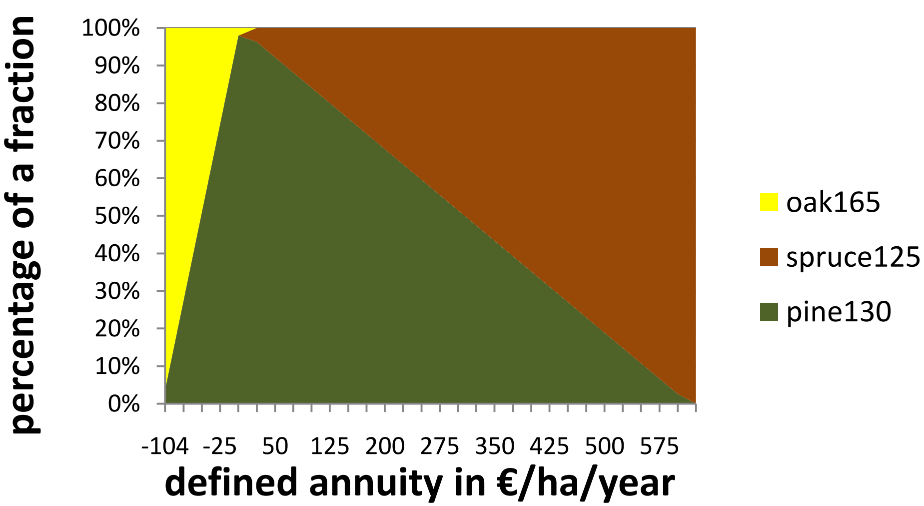
Standard deviation is the root of the sum of:

	oak small	pine big	spruce big
oak small	0.3*0.3* 6*6*(+1.00)	0.3*0.2* 6*18*(-0.07)	0.3*0.5* 6*19*(+0.05)
pine big	0.2*0.3*18*6*(-0.07)	0.2*0.2*18*18*(+1.00)	0.2*0.5*18*19*(+0.80)
spruce big	0.5*0.3*19*6*(+0.05)	0.5*0.2*19*18*(+0.80)	0.5*0.5*19*19*(+1.00)

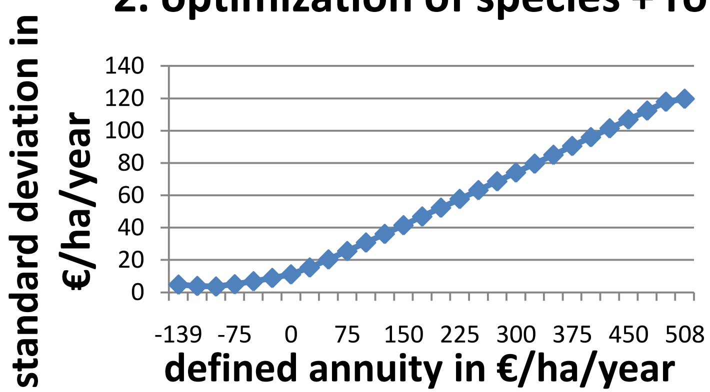
Assumptions and results: Several timber grades in each fraction, without natural hazard, i=2

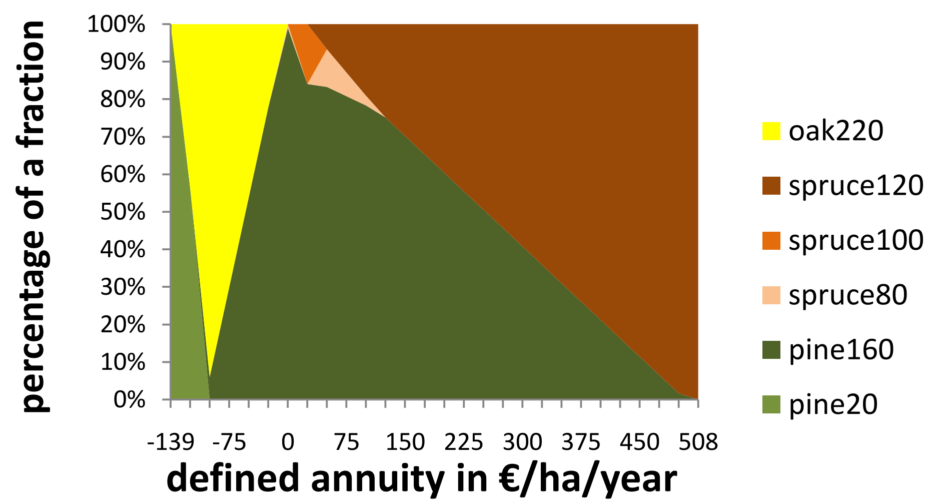
1. one rotation length per species
2. optimization of species fractions





1. rotation length in 20 year-steps
2. optimization of species + rotation





Conclusion

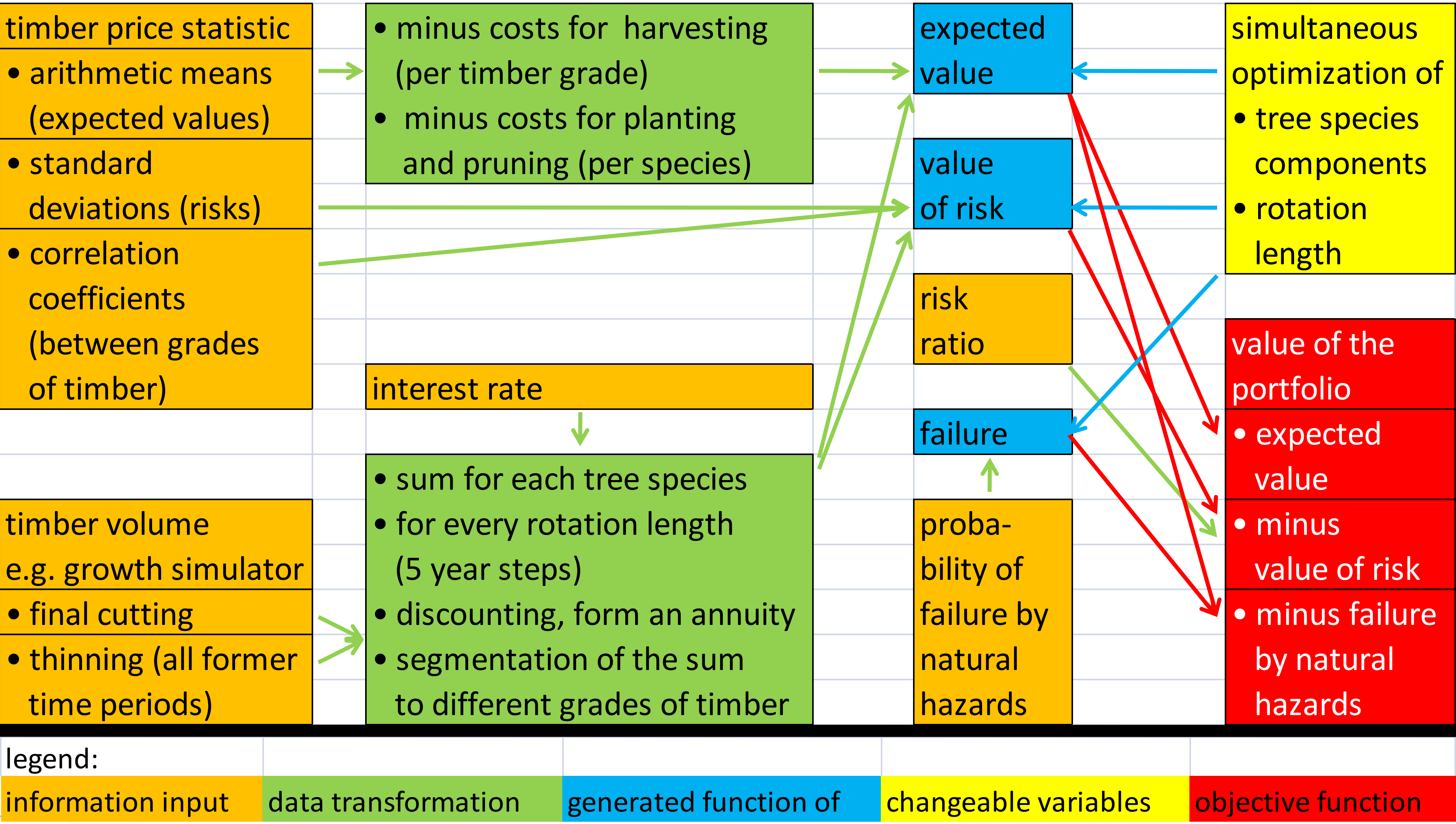
- The inclusion of risks can help to interpret the financial impacts of planning more realistic
- Diversification of the timber production leads to a better relation between risk and expected income for a forest enterprise
- Simultaneous optimization helps to advise the best management decisions for different factors

α

references

- Beinhofer, Bernhard (2009): Zur Anwendung der Portfoliotheorie in der Forstwissenschaft - Finanzielle Optimierungsansätze zur Bewertung von Diversifikationseffekten (dissertation)
- Faustmann, Martin (1849): Berechnung des Werthes, welchen Waldboden, sowie noch nicht haubare Holzbestände für die Waldwirtschaft besitzen. In: Allgemeine Forst- und Jagdzeitung, H. Dezember 1849, S. 442–455.
- Markowitz, Harry (1952): Portfolio selection. In: The Journal of Finance, Jg. 7, H. 1, S. 77–91.

Steps of the workprocess and necessary data



Optimization with the certainty equivalent

- Functions of expected value and standard deviation (data from timberprice statistic)

$$CEQ = E(r) - \alpha \times s_e^2/2$$ (Spremann 1996)

- E (r) expected value (arithmetic mean)
- α factor of risk aversion
- α= a / amount of investment (Spremann 1996)
- a=1 for normal; a=2 for strong risk aversion
- Failure of natural hazard: only half value

Different optimization assumptions

- Definition of optimization goal
  - Reach minimal risk for defined annuity
  - Reach maximal annuity for defined risk
- Changeable fractions of optimization
  - One best rotation length of each species
  - Fractions of defined rotation length per species
- Consideration of timber grades per fraction
  - Several timber grades in one species
  - Only one timber grade (then only final harvest)

Example data:				**Expected value is the sum of:**				**Standard deviation is the root of the sum of:**		
	s	a		EV of i	harvest	EV			oak small	pine big	spruce big
oak small	6	0.3		31	16	0.3*(31-16)		oak small	0.3*0.3* 6*6*(+1.00)	0.3*0.2* 6*18*(-0.07)	0.3*0.5* 6*19*(+0.05)
pine big	18	0.2		103	9	0.2*(103-9)		pine big	0.2*0.3*18*6*(-0.07)	0.2*0.2*18*18*(+1.00)	0.2*0.5*18*19*(+0.80)
spruce big	19	0.5		85	9	0.5*(85-9)		spruce big	0.5*0.3*19*6*(+0.05)	0.5*0.2*19*18*(+0.80)	0.5*0.5*19*19*(+1.00)