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GÖTTINGEN

Benefits from weather derivatives in agriculture: a portfolio optimisation using RISKOptimizer

Ulla Kellner, Dipl. Ing. agr.
und Prof. Dr. Oliver Mußhoff

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New Approaches to Risk & Decision Analysis

Outline

I. Motivation

II. Risk-management-instruments

III. Methodology

IV. Case studies

   i. Maerkisch Oderland: Diversification vs. weather derivatives

   ii. Lueneburger Heide: Weather derivatives vs. irrigation and diversification

V. Conclusion

“Climate is what we expect,

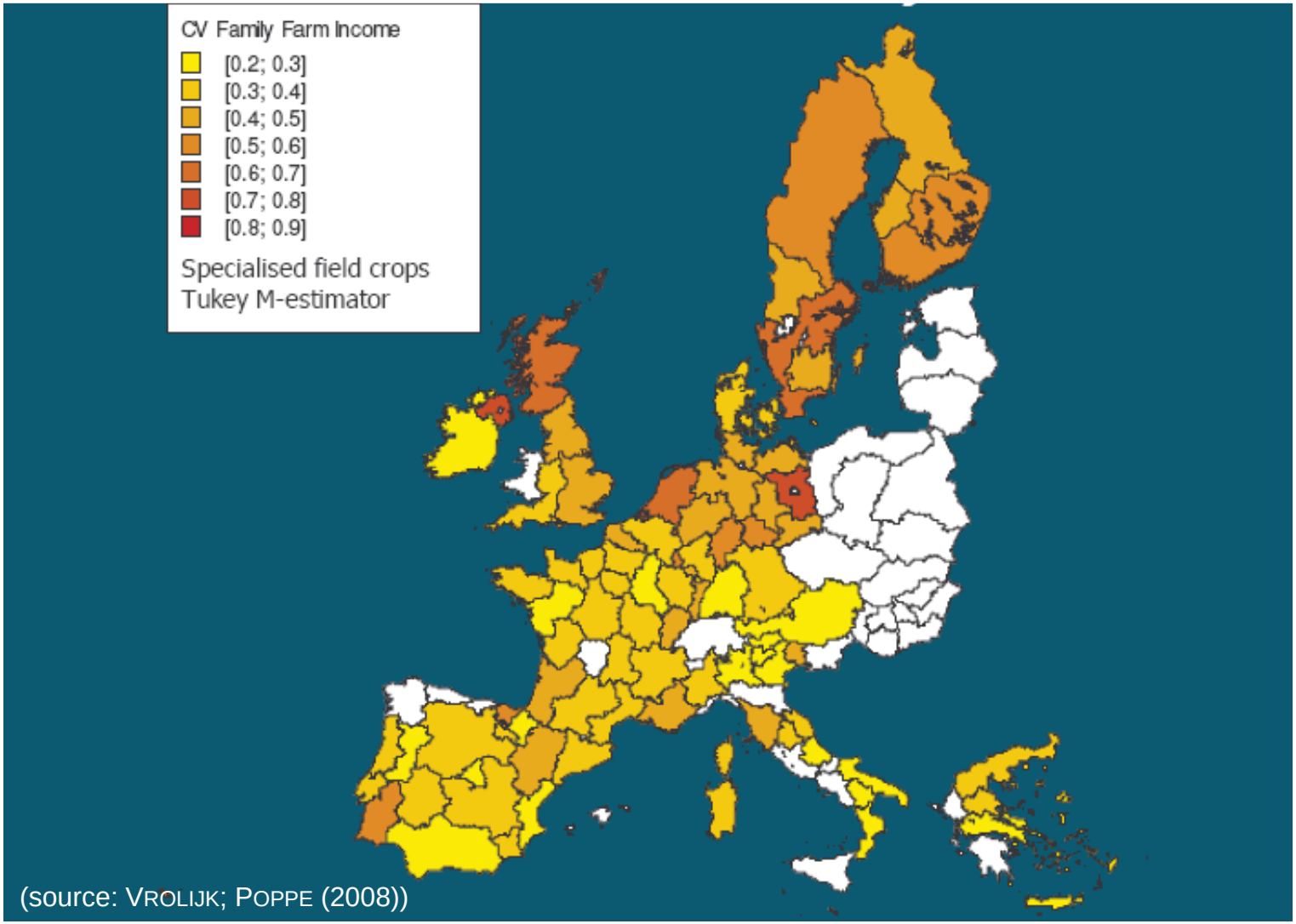
weather is what we get.”

(Mark Twain)

Motivation

- Crop production in general has a high sensitivity to weather
- Increase in risk
  - Market risk increases because of decreasing support in the European agriculture policy
  - Climate change causes a higher risk in yields
  - The production location plays an important role for crop farmers

Income volatility in crop farming



(source: VROLIJK; POPPE (2008))

Risk management instruments

1. On-farm risk management instruments
    - Diversification
    - Holding reserves
    - Holding overcapacities
    - **Irrigation**

2. Market-based risk management instruments
    - Contracts / commodity futures ➔ to hedge price risk
    - Insurance contracts

Risk management instruments

Insurances

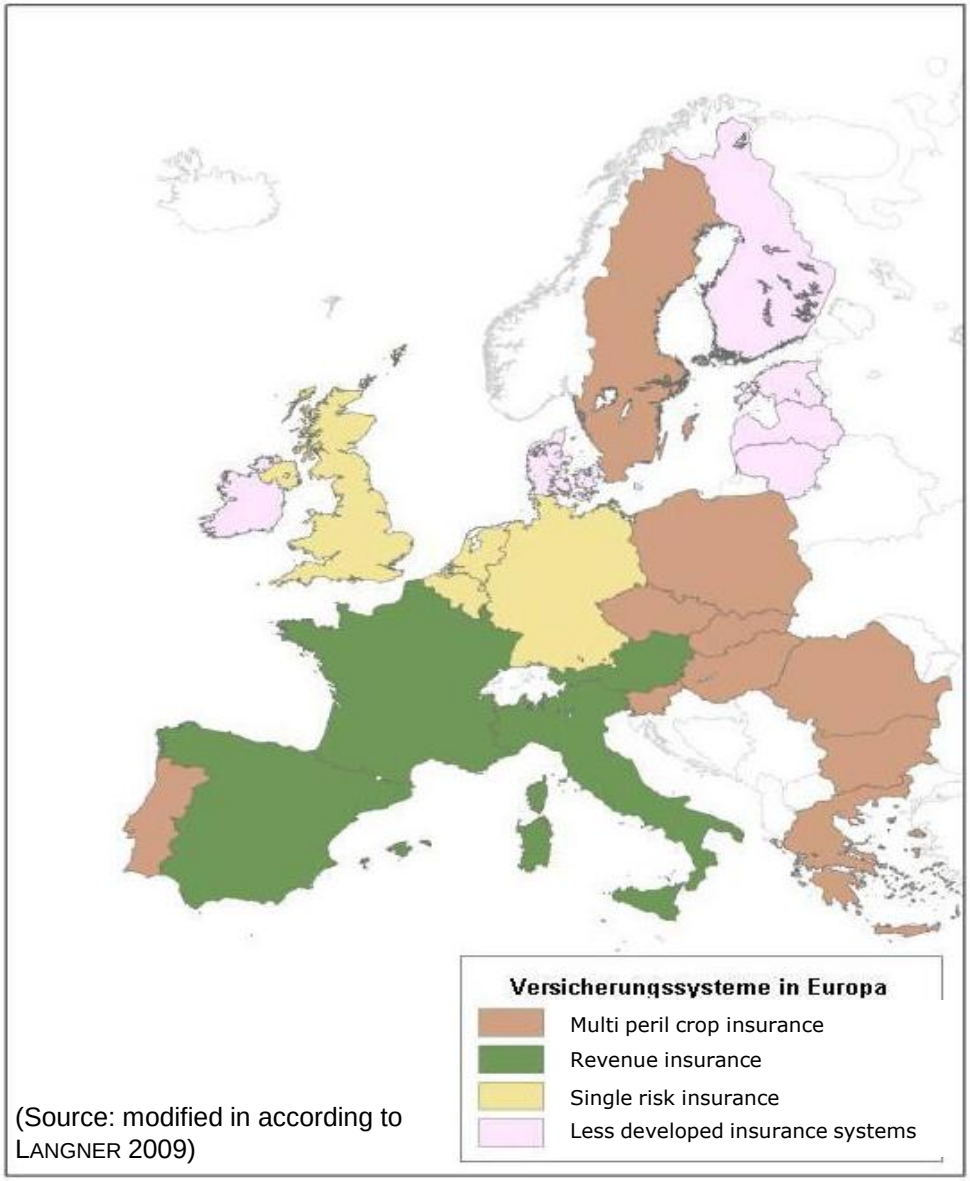
Damage-based insurances

- Disaster insurance ‘➔ yield risk
- Farm-income insurances (in form of a multi peril crop insurance) ➔ price and yield risk

Index-based insurances

- Regional-yield-based insurances ➔ price and yield risk
- **Weather derivatives** ➔ **yield risk**

Insurance systems in Europe



(Source: modified in according to LANGNER 2009)

Weather derivatives

Are available in Germany

Offered by http://www.celsiuspro.com/

Not common use in German Agriculture

Multi peril crop insurance:
Bulgaria, Cyprus, Czech Republic, Greece, Hungary, Portugal, Romania, Slovakia, Slovenia, Sweden

Yield insurance:
Spain, Italy, France, Austria and Luxembourg

Disaster insurance:
Belgium, Germany, Netherlands and United Kingdom

Less developed insurance systems: Denmark, Ireland, Finland und the Baltic States

Damage-based insurance		Index-based insurance	
Disaster insurance	Multi peril crop insurance	Regional index insurance	Weather derivative
Certain indemnity payments	Certain indemnity payments	Uncertain indemnity payments (basis risk)	Uncertain indemnity payments (basis risk)
Only insurance against disaster	Insurance against some other incidence	Insurance against some other incidence	Insurance against some other incidence
High transaction costs	High transaction costs	Low transaction costs	Low transaction costs
Low moral-hazard-costs	High moral-hazard-costs	Low moral-hazard-costs	No moral-hazard-costs

Research questions

- How much benefit can weather derivatives bring for crop farmers in drought periled regions in Germany?
- Are weather derivatives suitable to cover yield risks in the context of reduced water withdrawal permits?

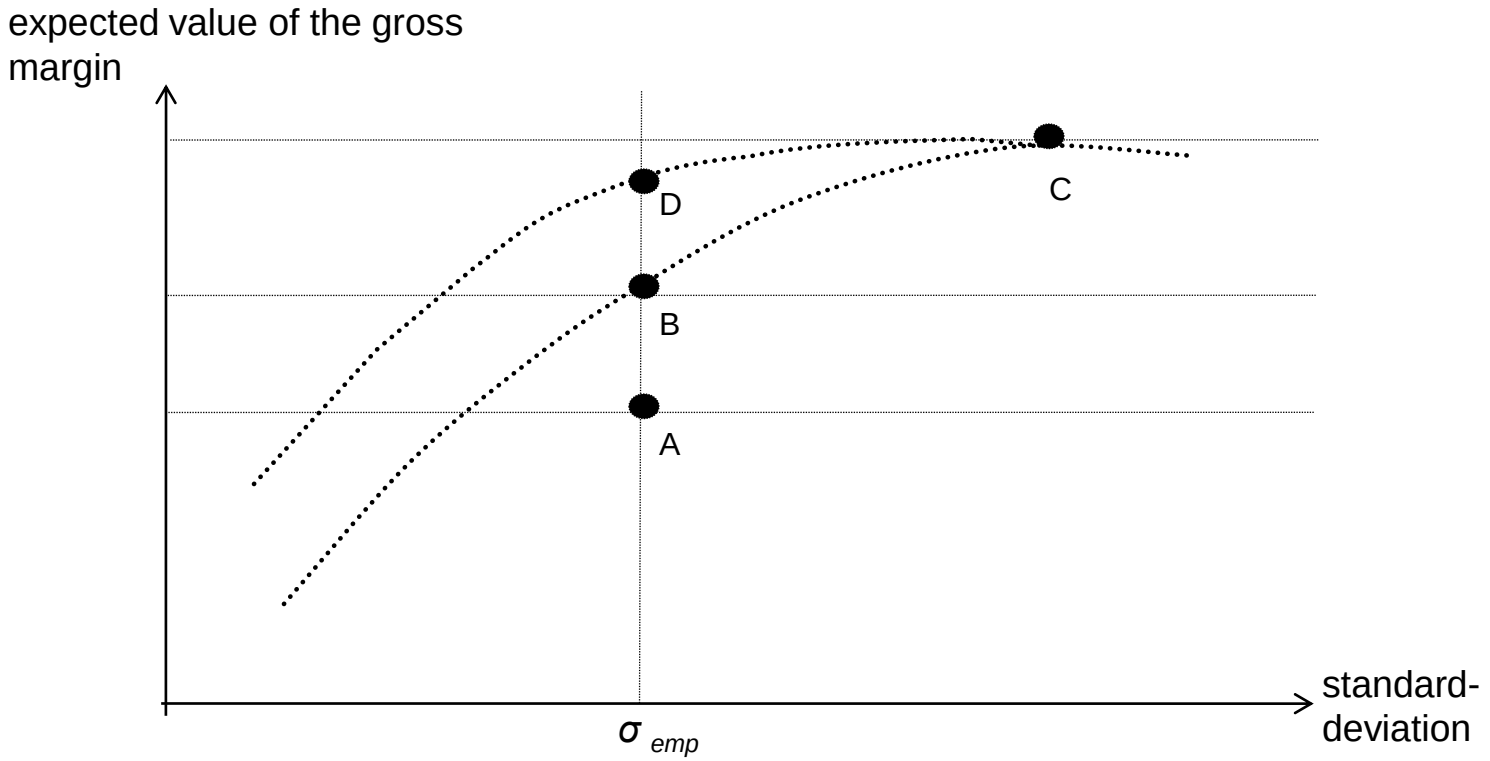
Method

- Whole farm risk programming approach
- Activities: different crops and weather derivatives, as well as seasonal work
- Restrictions: amount of land, own labour force, crop rotation and risk

➔ Objective function: maximization of the total gross margin by having the same risk

➔ Quadratic optimization problem

Measuring the already accepted risk



A: empirically observed production program
B: optimized production program in compliance with the accepted risk
C: production program which could bring the maximum amount of gross margin
D: production program with risk management instruments

σ_{emp}: standard deviation of the empirically observed production program

Method

- At first: calculation with GAMS ➔ quick answer
- Problem: normal distribution for all components as a must
  - For weather derivatives not given, because of pay off structure (asymmetrical distribution)

➔ Genetic algorithm and stochastic simulation as a solution

In the first step: hand made GA with stochastic simulation

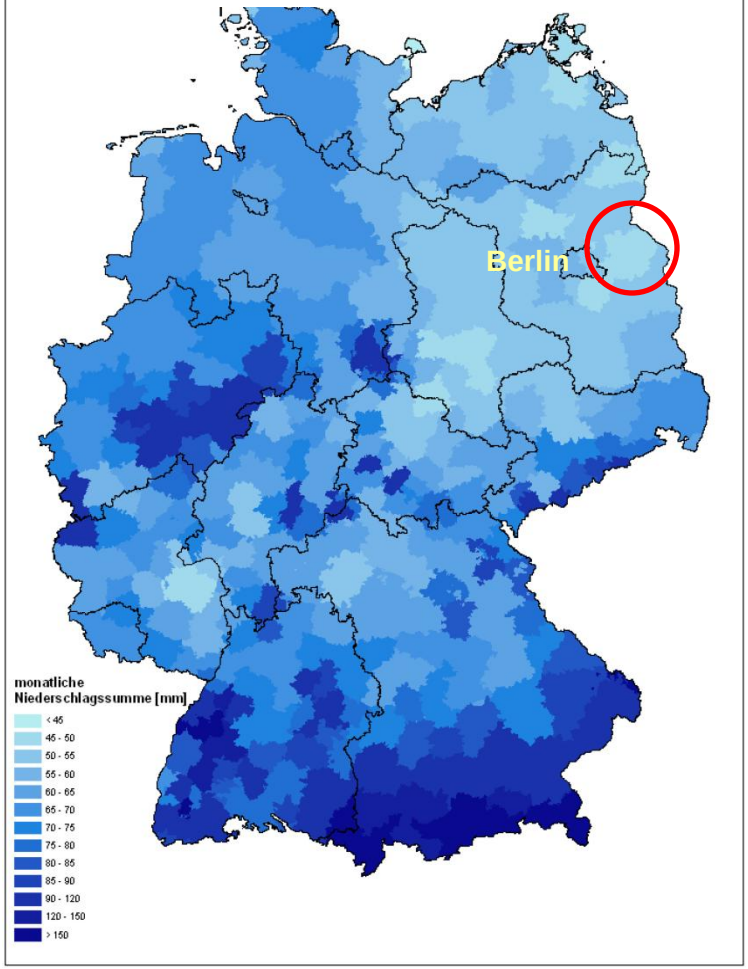
But: too much work for just one single farm

➔ RISKOptimizer as good solution

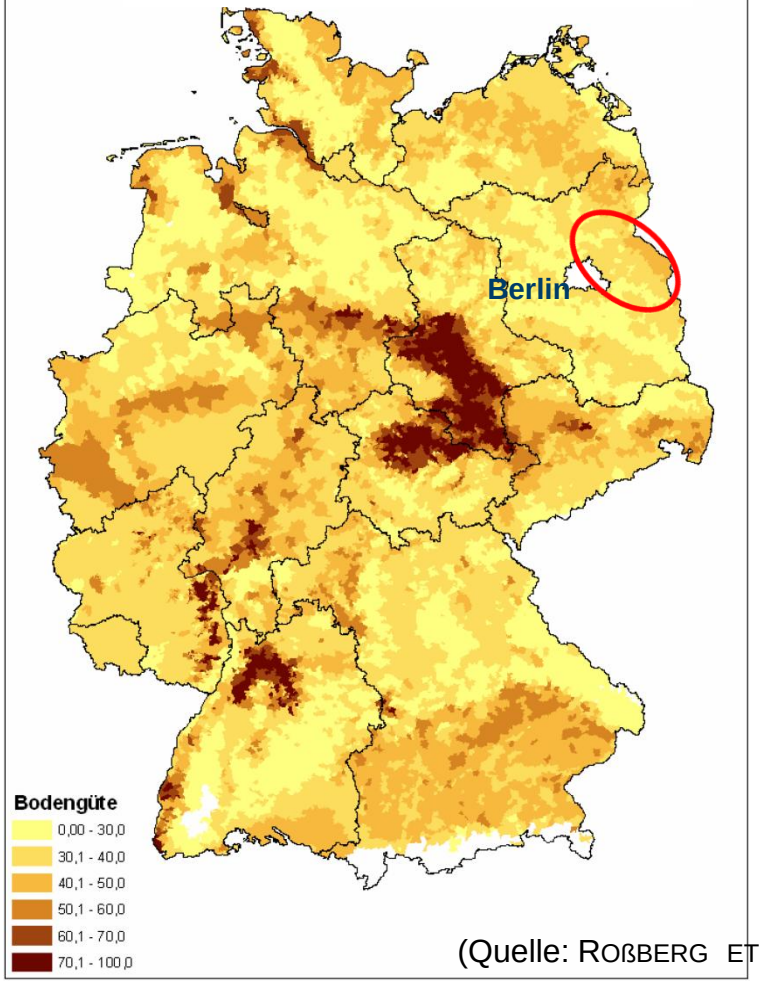
Case Study : Maerkisch-Oderland

Soil and Climate in Germany

Average of the Monthly rainfall (period March- August)



Average of the soil quality



(Quelle: ROßBERG ET AL. 2007)

Data

Average of eight crop farms in North-East Germany (Maerkisch-Oderland)

- Time series1995/1996 – 2007/2008
- On average 571ha
- Nine different cropping activities :
  - winter wheat
  - winter rye
  - winter barley
  - summer barley
  - oat
  - triticale
  - fodder peas
  - winter canola
  - sugar beat

– Set aside also allowed

– Yield data and the prices were extracted out of the so called **F**ederal **A**ccounting **D**ata **N**etwork („Testbetriebsnetz“), variable cost is calculated out of data of the ministry for agriculture in Brandenburg (LVLF)

➔ gross margin

Weather derivative specification Maerkisch-Oderland

	Derivative April
Typ	Put-Option
Payoff	$V \bullet \max(K-I_t ; 0)$
Index (I)	$\sum_{t=01.04.}^{30.04.} y_t$
Strikelevel (K)	90 mm
Tick-Size (V)	1 mm
Premium	**23.96 €**

Daily precipitation rate from the weather station „Muencheberg“

Correlations

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	winter wheat	Winter rye	winter barley	summer barley	oat	triticale	fodder peas	winter rape	sugar beats	wheater derivative
expected value	**614,89**	**442.64**	**441.29**	**451.30**	**541.56**	**442.87**	**425.79**	**550.32**	**1,883.73**	**0.00**
standard deviation	**171.40**	**220.60**	**181.20**	**209.79**	**168.52**	**186.11**	**171.91**	**208.43**	**594.82**	**23.96**
winter wheat	1									
winter rye	0.359	1								
winter barley	0.602	0.588	1							
summer barley	0.516	0.502	0.490	1						
oat	0.610	-0.161	-0.137	0.020	1					
triticale	0.605	0.852	0.623	0.548	0.101	1				
fodder peas	0.487	-0.224	0.024	0.486	0.495	0.047	1			
winter rape	0.652	0.018	0.507	0.293	0.134	0.209	0.250	1		
sugar beats	-0.321	0.039	0.060	0.008	-0.633	-0.105	-0.282	0.101	1	
wheater derivative	-0.442	-0.308	-0.184	-0.415	-0.051	-0.435	-0.318	-0.231	-0.004	1

„Prove of RISKOptimizer“

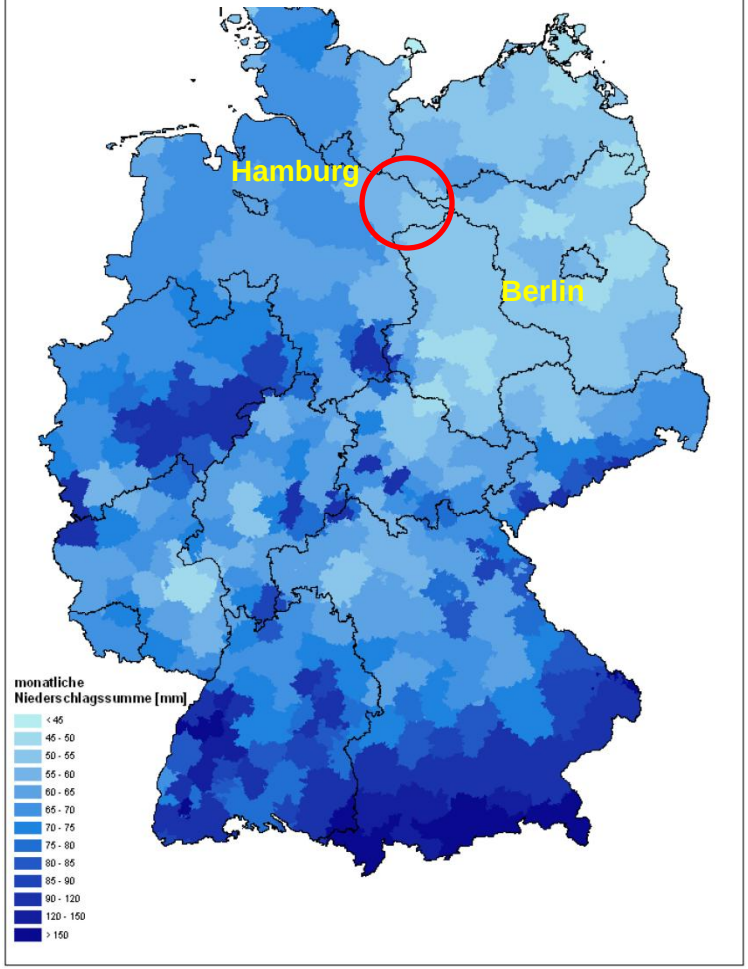
		Expected value of total gross margin	Standard deviation
Empirical observed production program		253 520	53 623
Risk-Optimizer	Optimization without weather derivatives [a)]	311 081	53 969
	Optimization with weather derivatives [a)]	322 060	53 291
GAMS	Optimization without weather derivatives [a)]	310 670	53 623
	Optimization with weather derivatives [a)]	319 980	53 623

[a)] Standard deviation 53 623 €.

Case Study : Lueneburger Heide

Soil and Climate in Germany

Average of the Monthly rainfall (period March- August)



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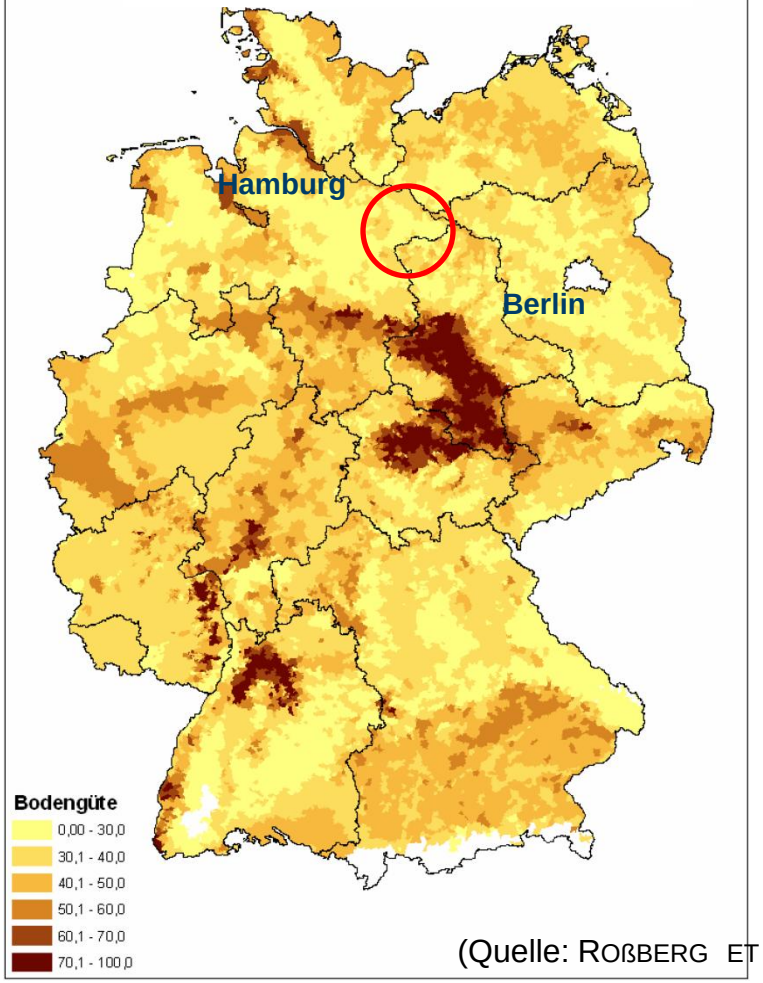


(Quelle: ROßBERG ET AL. 2007)

Data

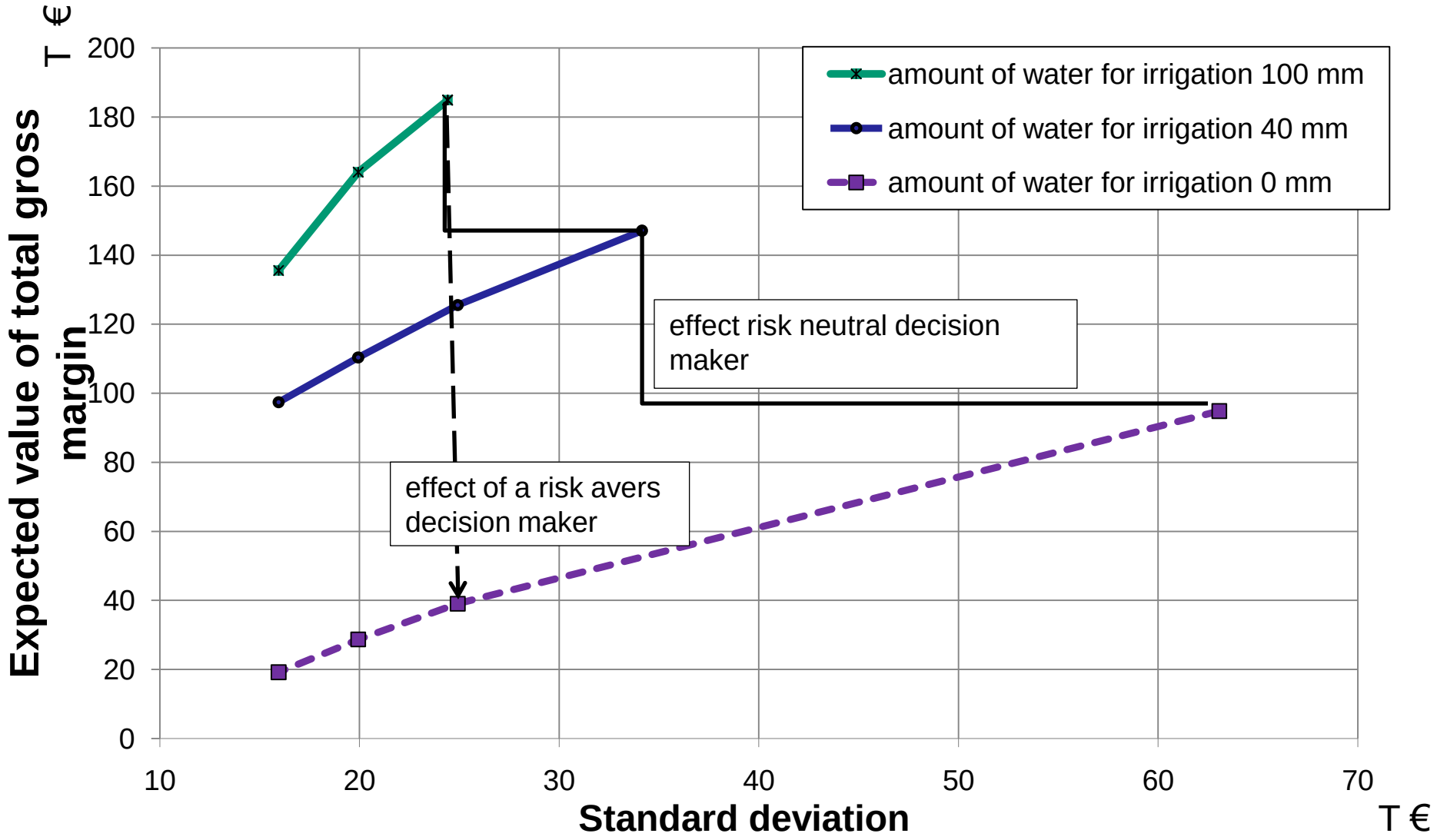
- Time series (1982-2006)

- Four different cropping activities
  - Winter barley
  - Summer brewing barley
  - Potatoes
  - Sugar beet

  ➔**Gross margin**

- Daily precipitation rates from the weather station in „Suderburg“

Irrigation as a risk management instrument



Weather derivative specification for the „Lueneburger Heide“

Time horizon	June	July	June - July	April-August	June-August
Payoff	V • max $(K-I_t,0)$				
Index (I)	$\sum_{t=01.06.}^{30.06.} y_t$	$\sum_{t=01.07.}^{31.07.} y_t$	$\sum_{t=01.06.}^{31.07.} y_t$	$\sum_{t=01.04.}^{31.08.} y_t$	$\sum_{t=01.06.}^{31.08.} y_t$
Strike Preis (K)	69.8 mm	68.8 mm	138.6mm	298.6 mm	199.1 mm
Tick size (V)	1 mm				
Fair premium	10.89 €	13.24 €	17.30 €	24.69 €	18.89 €
Premium with 20% load	13.07 €	15.88 €	20.76 €	29.63 €	22.67 €

Results

	Expected value of the total gross margin
Without irrigation and without weather derivatives	43 505 €
With weather derivatives	51 301 €
With weather derivatives for the fair premium	60 750 €

With a limit for the standard deviation of 27 279 €.

Conclusion

- With a whole risk programming approach we are able to estimate the impacts of risk management instruments
- Weather derivatives can bring a higher expected value with the same level of standard deviation
- It is important to have different periods for the weather derivatives
- Weather derivatives could compensate a reduction in the water withdrawal permits

- With the RISKOptimizer we can calculate very quickly a lot of farms and let students work with it, too.

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Thank you very much for your attention!

Contact:

Dipl. Ing. agr. Ulla Kellner

Georg-August-University of Goettingen
Department for Agricultural Economics and rural Development
Platz der Goettinger Sieben 5
D-37073 Goettingen
Tel.: +49 (0) 551 / 39-9321
ulla.kellner@agr.uni-goettingen.de