



***Price and Yield Risks on
Agricultural Markets in
Germany and the EU:
Implications for Farm Management
and Agricultural Policy***

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Outline

1. Background and objectives
2. Statistical analysis of agricultural price risk
3. Risk exposure and vulnerability of farms
4. Summary and Implications for agricultural policy



Background and motivation

- Agricultural production is exposed to high risks
 - Climate change may further increase stochasticity of yields
 - Stochastic yields result in high price fluctuations due to unelastic demand and supply
 - Deregulation of markets further increase price volatility
- => Yield and price risk translate into income risk that may jeopardize farm households



Objectives

- Measurement of price and yield risks for important agricultural commodities
- Test of hypothesized increase in price risk
- Impact of increased yield risk on price volatility
- Impact analysis on farm level



Methods & Data

I Time series analysis

ARIMA

LRHA and EWMA estimates of price volatility

GARCH model

II Stochastic simulation

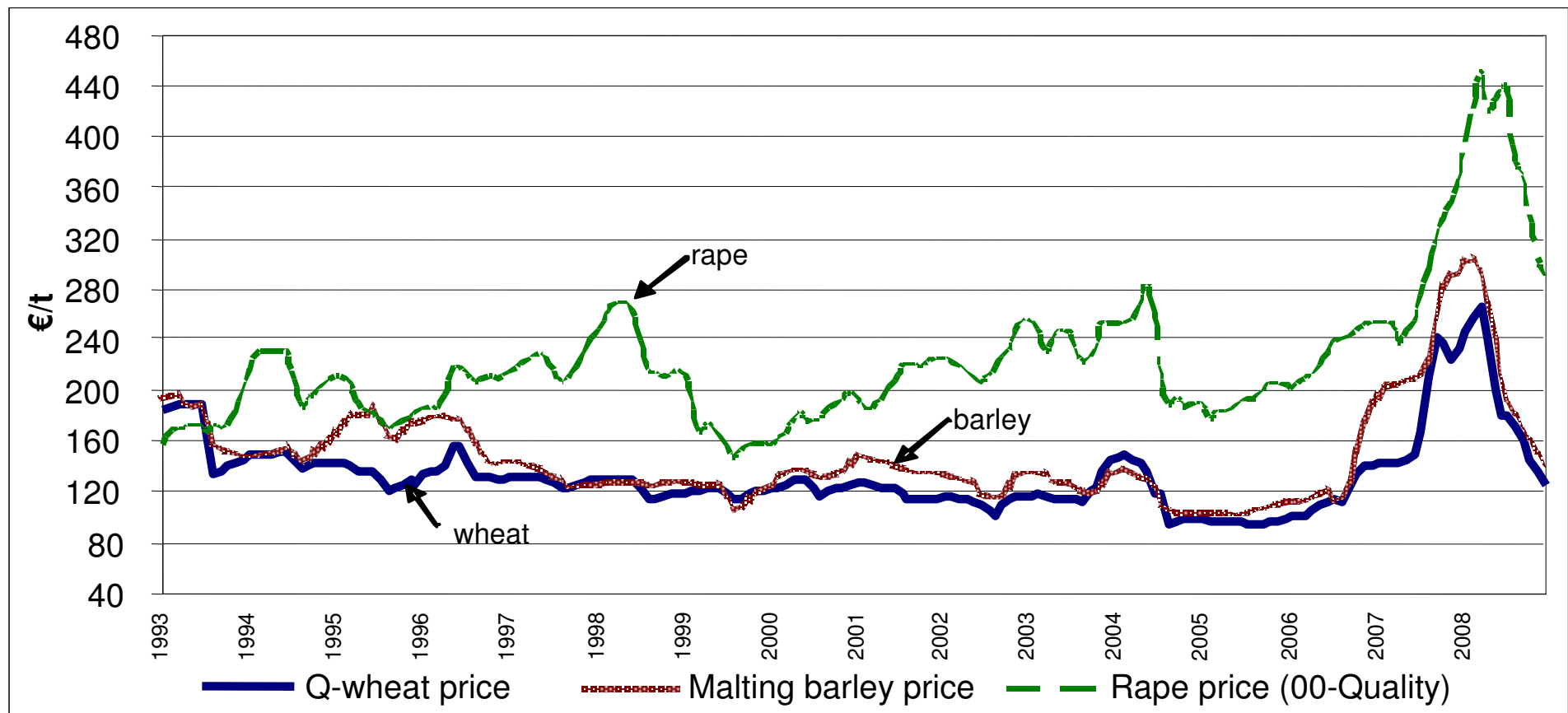
III Stochastic market model (ESIM)

VI Data

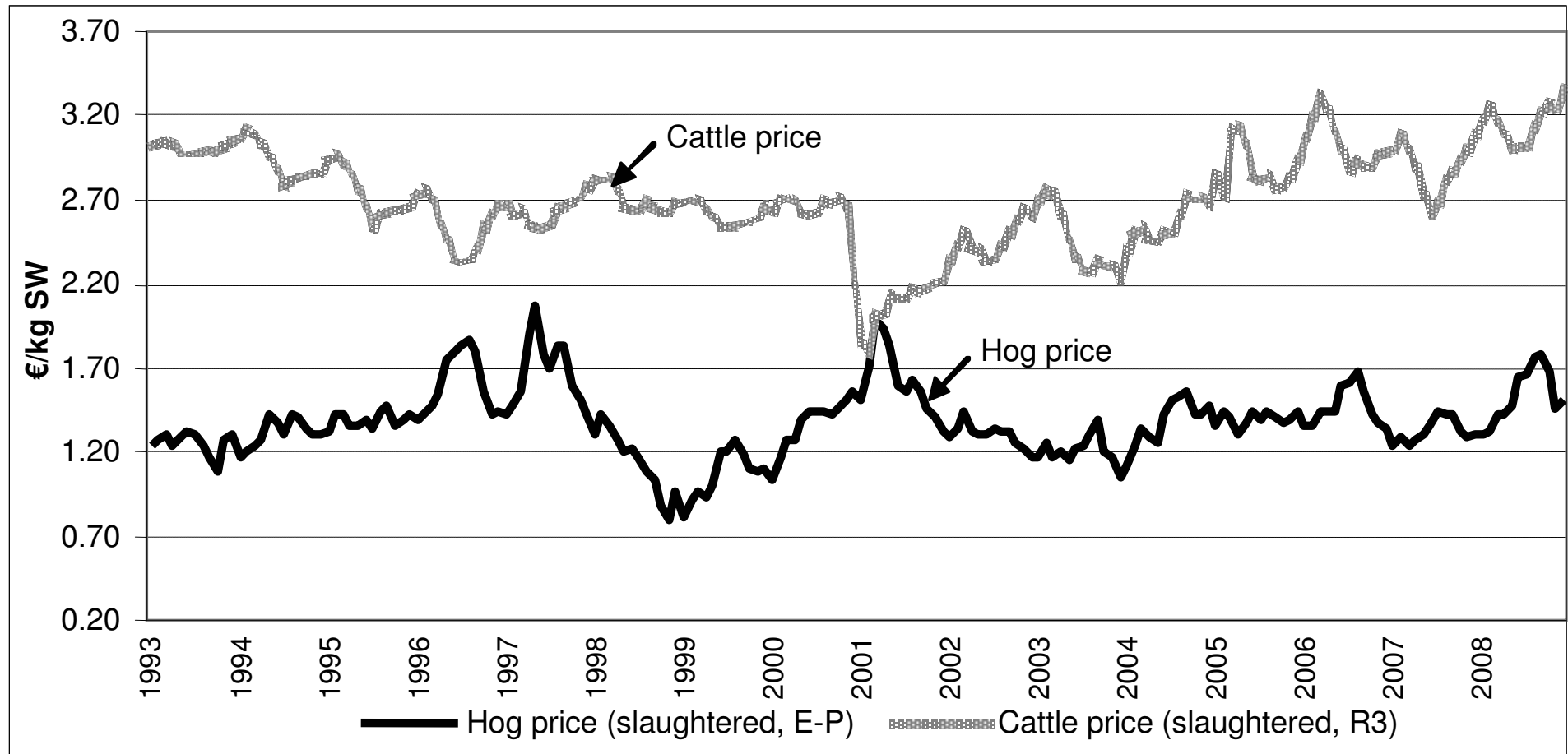
Prices: ZMP, EUROSTAT

Yields: FAOSTAT

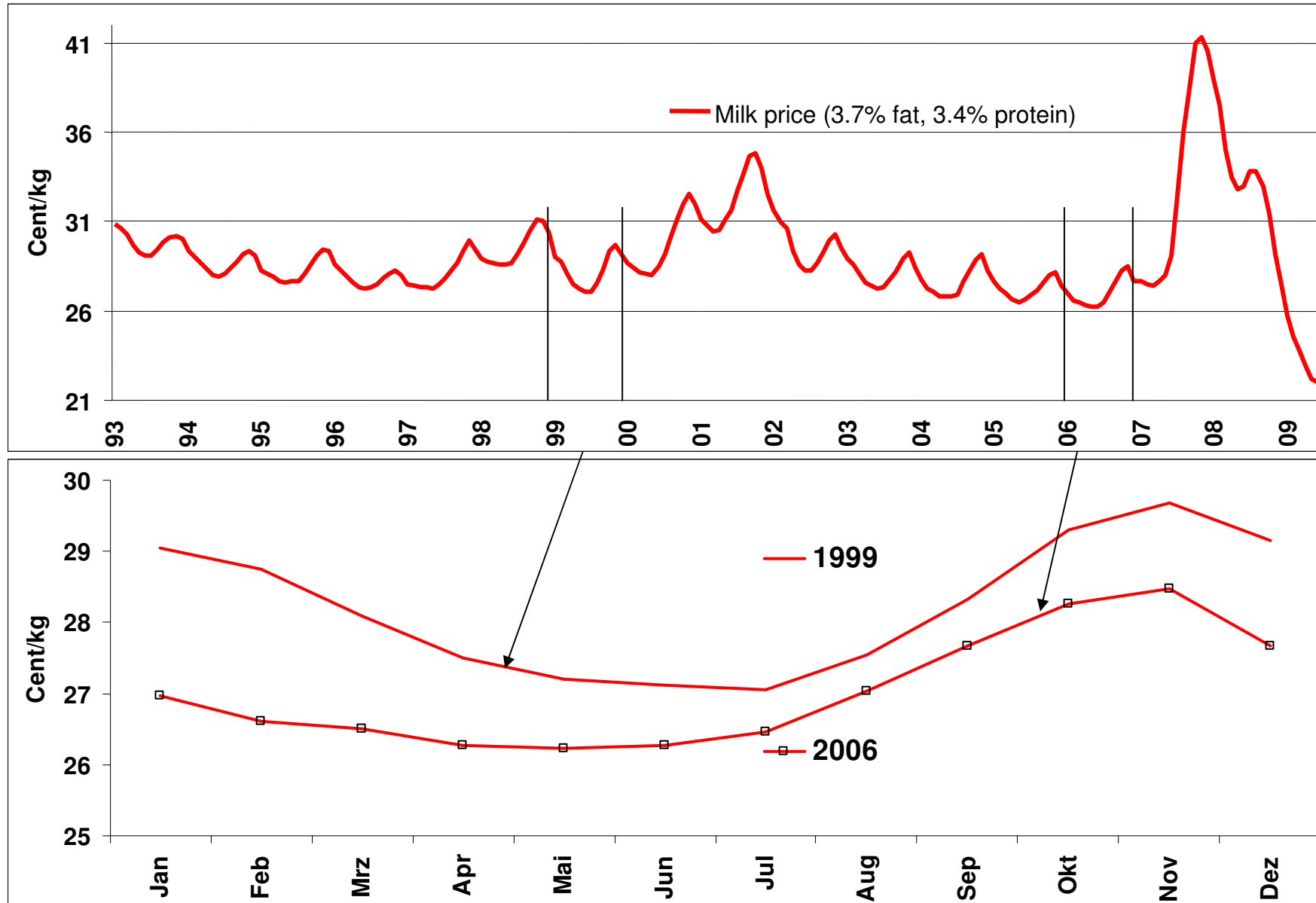
Producer prices for wheat, barley, rape (Germany 01/93 - 12/08)



Producer prices for hogs and cattle (Germany 01/93 - 12/08)



Milk Price (Germany)



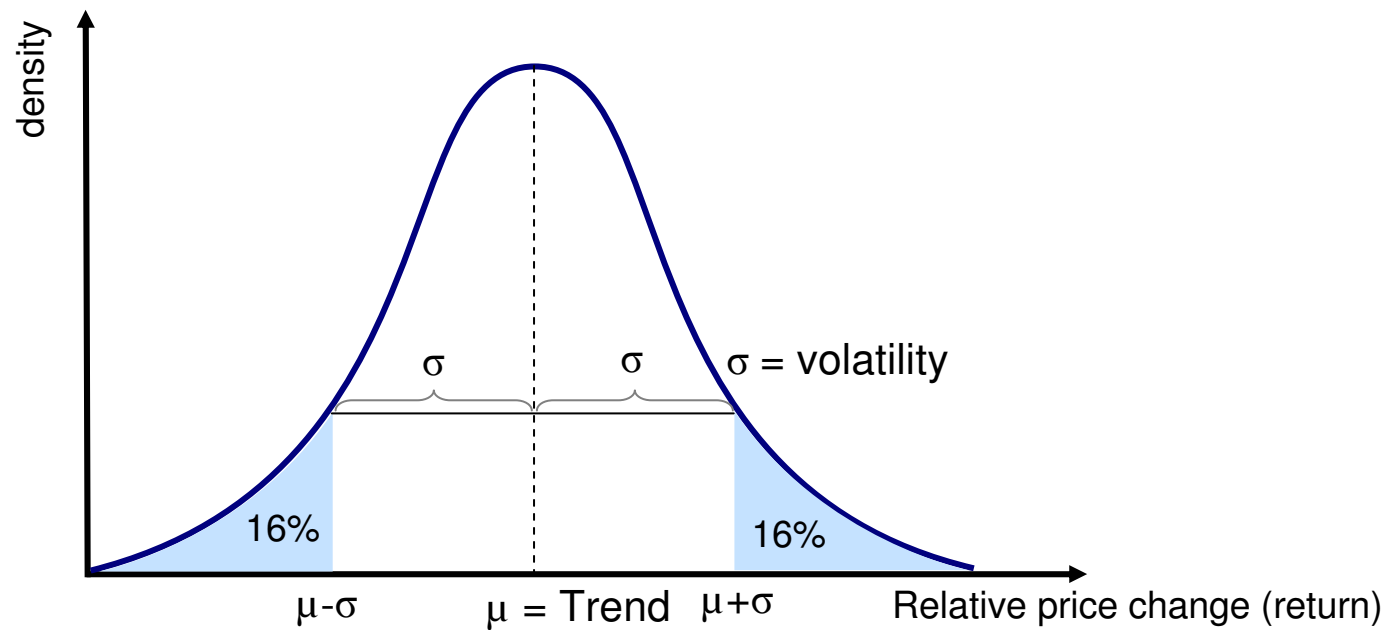
Volatilities of selected agricultural commodity prices

Period	01/93-12/08		P1: 01/93-12/00	P2: 01/01-12/04	P3: 01/05-12/08
	LRHA ^a	EWMA ^b	LRHA	LRHA	LRHA
Wheat	16.95%	27.58%	13.20%	17.03%	22.92%
Barley	13.92%	24.08%	10.34%	10.68%	21.34%
Rape	15.81%	21.74%	14.80%	17.12%	16.68%
Milk (3,7 % fat, 3,4 % proteine)	8.06%	14.96%	5.25%	6.98%	12.52%
Hogs (slaughtered, E-P)	23.27%	20.04%	25.51%	23.08%	18.19%
Cattle (slaughtered, R3)	11.92%	10.14%	9.59%	11.99%	12.53%

^a Long run historical average

^b Exponentially weighted moving average

Interpretation of price volatility



Example: average wheat price P_W : 13 €/dt

Volatility 0,17 (= 17 %)

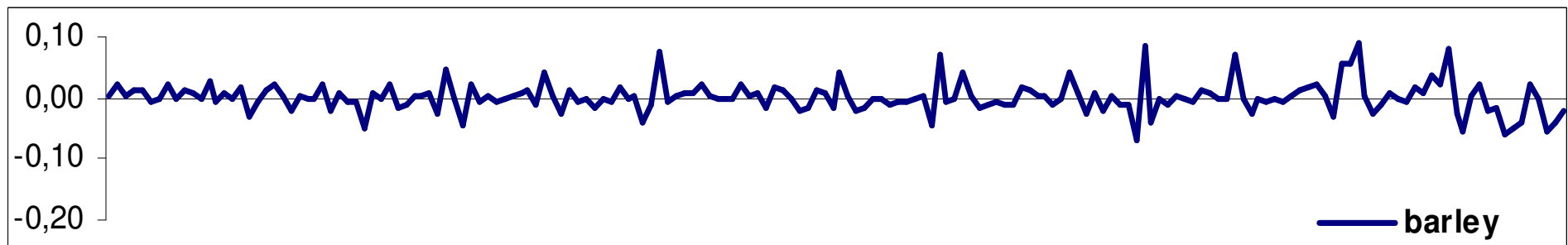
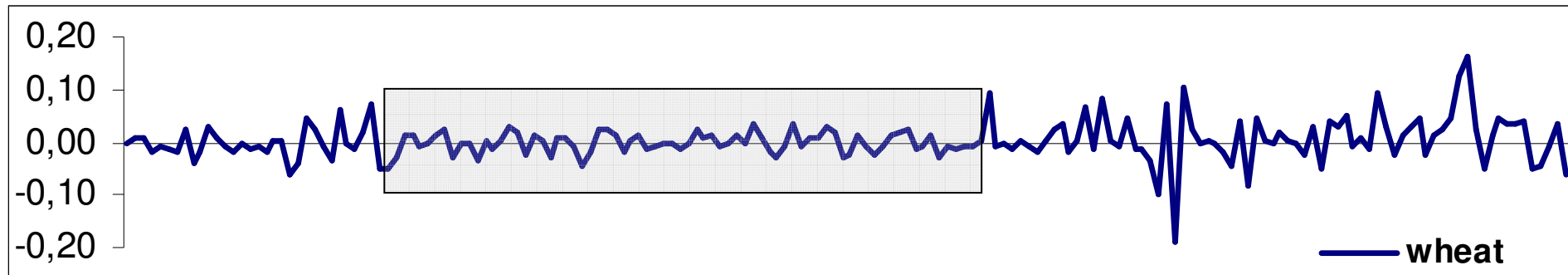
$\mu = 0$

1 σ - bound for wheat price: $13 \pm 0,17 \cdot 13$

$\Rightarrow P(10,8 \leq P_W \leq 15,2) = 0,68$

$P(P_W \leq 10,8) = 0,16$

ARIMA residuals of log prices

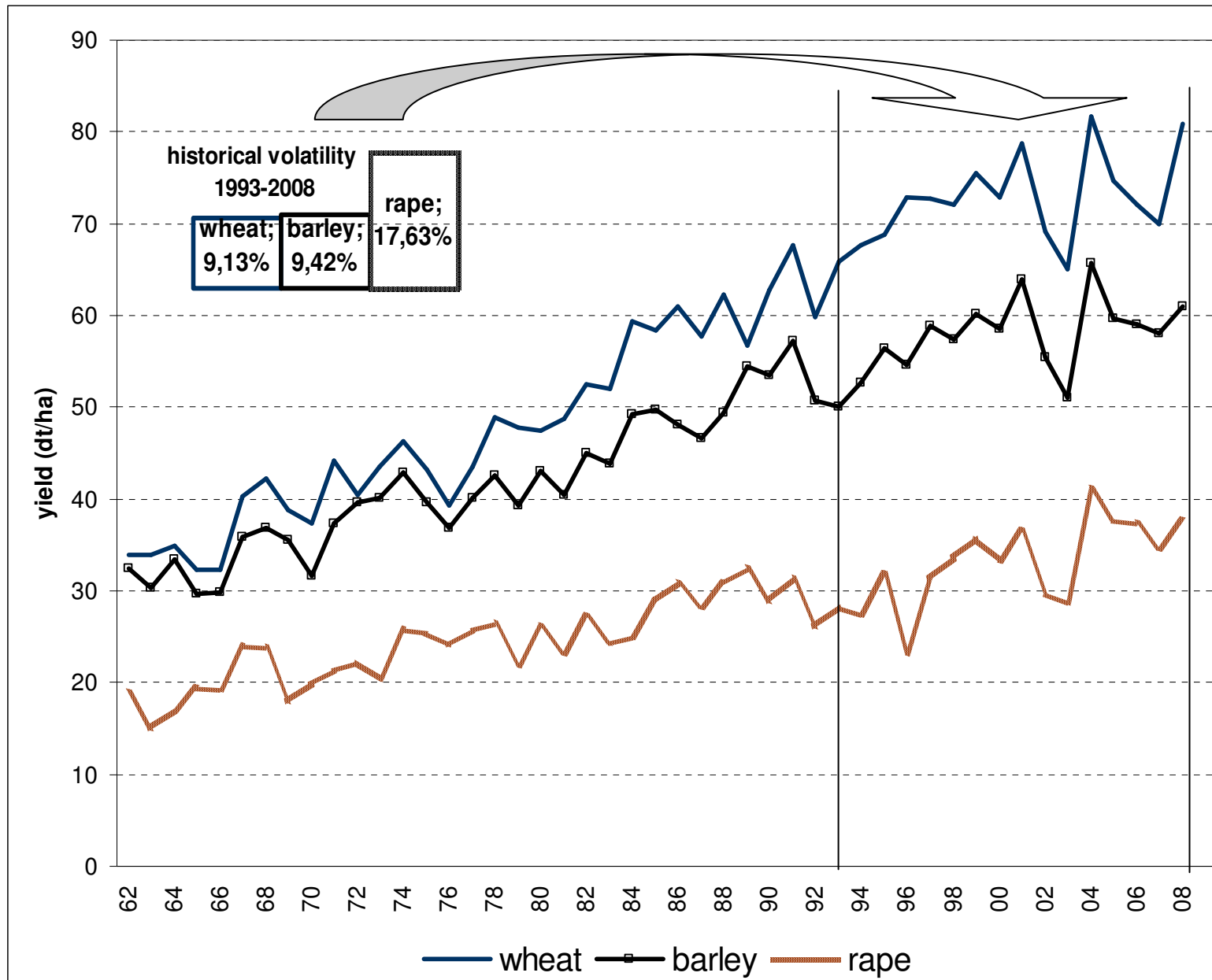




Volatilities of agricultural prices in Europe

1993-2008	wheat	barley	rape	milk	hogs	oxen
Belgium	0,16	0,16	0,15	0,12	0,16	
Denmark	0,15	0,14	0,1	0,11	0,14	0,08
Germany	0,17	0,16	0,15	0,07	0,18	
Finland	0,25	0,22	0,28	0,03	0,11	
France	0,07	0,06	0,14	0,05	0,29	0,01
Greece	0,14	0,11		0,09		
Ireland	0,23	0,1		0,1		0,06
Italy	0,05	0,04	0,15			
Luxembourg	0,15	0,17	0,15			
Netherlands	0,19	0,1	0,12	0,08		0,17
Austria	0,25	0,19	0,26	0,08	0,2	0,09
Poland	0,24	0,23	0,21			
Portugal	0,13	0,14		0,07	0,15	0,08
Rumania	0,34	0,32	0,38	0,06	0,16	0,17
Sweden	0,17	0,16	0,21	0,09	0,07	
Spain	0,12	0,12	0,11	0,07		
Hungary	0,31	0,33	0,15			
England	0,12	0,11	0,14	0,08		0,06

Development of yields (Germany)





Implications of price and yield risks for farms

What is the impact of the observed price and yield risk on farm incomes?

- farm level analysis
- consideration of joint risks and correlations

Distributions and correlations of prices and yields

Correlation	Wheat yield	Barley yield	Rape yield	Wheat price	Barley price	Rape price
Wheat yield	1					
Barley yield	0,887	1				
Rape yield	0,571	0,746	1			
Wheat price	-0,069	-0,265	-0,218	1		
Barley price	-0,137	-0,251	-0,272	0,935	1	
Rape price	0,014	-0,206	-0,276	0,723	0,626	1
Distribution	Extreme value	Logistic	Extreme value	Log logistic	Inverse Gauss	Log logistic

Yield and price risk in cash crop farms

Year 2007/08		All farms
Land	ha LF	114
Labor	LU/100 ha LF	1.6
Cereal yield	dt/ha	62.3
Profit 2007/08	€/ha LF	527
Profit based on average yields and prices	€/ha LF	417
ROE (Profit - imputed wages (37034 €))	€/farm	10.401
Stochastic yields, deterministic prices (average 1993-2008)		
Profit 5 % quantile	€/ha	342
ROE	€/farm	1.928
Cases with negative ROE	%	2
Stochastic prices, deterministic yields (average 1993-2008)		
Profit, average	€/ha	417
Profit, 5 % quantile	€/ha	262
ROE, 5% quantile	€/farm	-7.235
Cases with negative ROE	%	23
Stochastic yields and prices,		
Profit 5 % quantile	€/ha LF	240
ROE 5% quantile	€/farm	-9.657
Cases with negative ROE	%	26



Modelling of price volatility (ex ante)

- Model basis: stochastic version of ESIM
- Estimation of yield risk (historical data)
- Calibration of the simulation model for the observed price volatility (base scenario)
- Analysis of a hypothetical increase of yield risk relative to base scenario

Impact of increasing Yield risk on price volatility (Germany, 2015)

Coefficient of variation for ...	Base scenario	5 %	10 %	15 %	20 %
Wheat					
Yields	6,5	6,9	7,2	7,5	7,8
Prices	23,6	25,5	27,5	29,7	32,1
Barley					
Yields	6,9	7,3	7,6	7,9	8,3
Prices	26,5	28,4	30,4	32,4	34,7
Raps					
Yields	10,4	10,9	11,4	12,0	12,5
Prices	20,2	21,2	22,2	23,2	24,3



Summary and policy conclusions

- Farmers:** Awareness of price risks and knowledge of risk management strategies
- Extension:** Enhancement of deterministic analyses; familiarization with stochastic analysis
- Insurance:** Supply of appropriate and affordable insurance products
- Policy:**
- Provision of data
 - Financial support in catastrophic events; no regular subsidies for insurance premia

ARIMA- models for monthly prices (Germany, 1993 - 2008)

parameter	estimation	std.-error	t	p-value
wheat ARIMA(0,1,2)(1,1,2)9 RMSE 5,2992				
MA(1)	-0,5066	0,0717	-7,0621	0
MA(2)	-0,3044	0,0715	-4,2575	0
SAR(1)	0,2535	0,0814	3,1127	0,0022
SMA(1)	1,7265	0,0291	59,2917	0
SMA(2)	-0,7562	0,0271	-27,933	0
barley ARIMA(1,1,1)(0,1,1)12 RMSE 4,07398				
AR(1)	0,6651	0,0785	8,4745	0
MA(1)	-0,185	0,0991	-1,8677	0,0635
SMA(1)	0,8706	0,0239	36,4025	0
rape ARIMA(1,1,0)(0,1,1)12 RMSE 10,3501				
AR(1)	0,5085	0,065	7,8279	0
SMA(1)	0,8719	0,0218	40,0098	0
milk ARIMA(2,0,0)(0,1,1)12 RMSE 0,36095				
AR(1)	1,7654	0,0445	39,6741	0
AR(2)	-0,8021	0,0445	-18,0265	0
SMA(1)	0,7158	0,0487	14,6912	0
hogs ARIMA(1,0,0)(1,0,1)12 RMSE 0,0824067				
AR(1)	0,9438	0,0246	38,3799	0
SAR(1)	1,0125	0,0254	39,7853	0
SMA(1)	0,8655	0,0629	13,7536	0
cattle ARIMA(0,1,2)(0,0,1)12 RMSE 0,0789148				
MA(1)	-0,4741	0,0713	-6,6463	0
MA(2)	-0,2599	0,0711	-3,6574	0,0003
SMA(1)	-0,217	0,0722	-3,0035	0,003
RMSE = root mean squared error				



Risk coping strategies

- Risk retention
- Risk avoidance
- Risk reduction
- Risk sharing
- Risk transfer

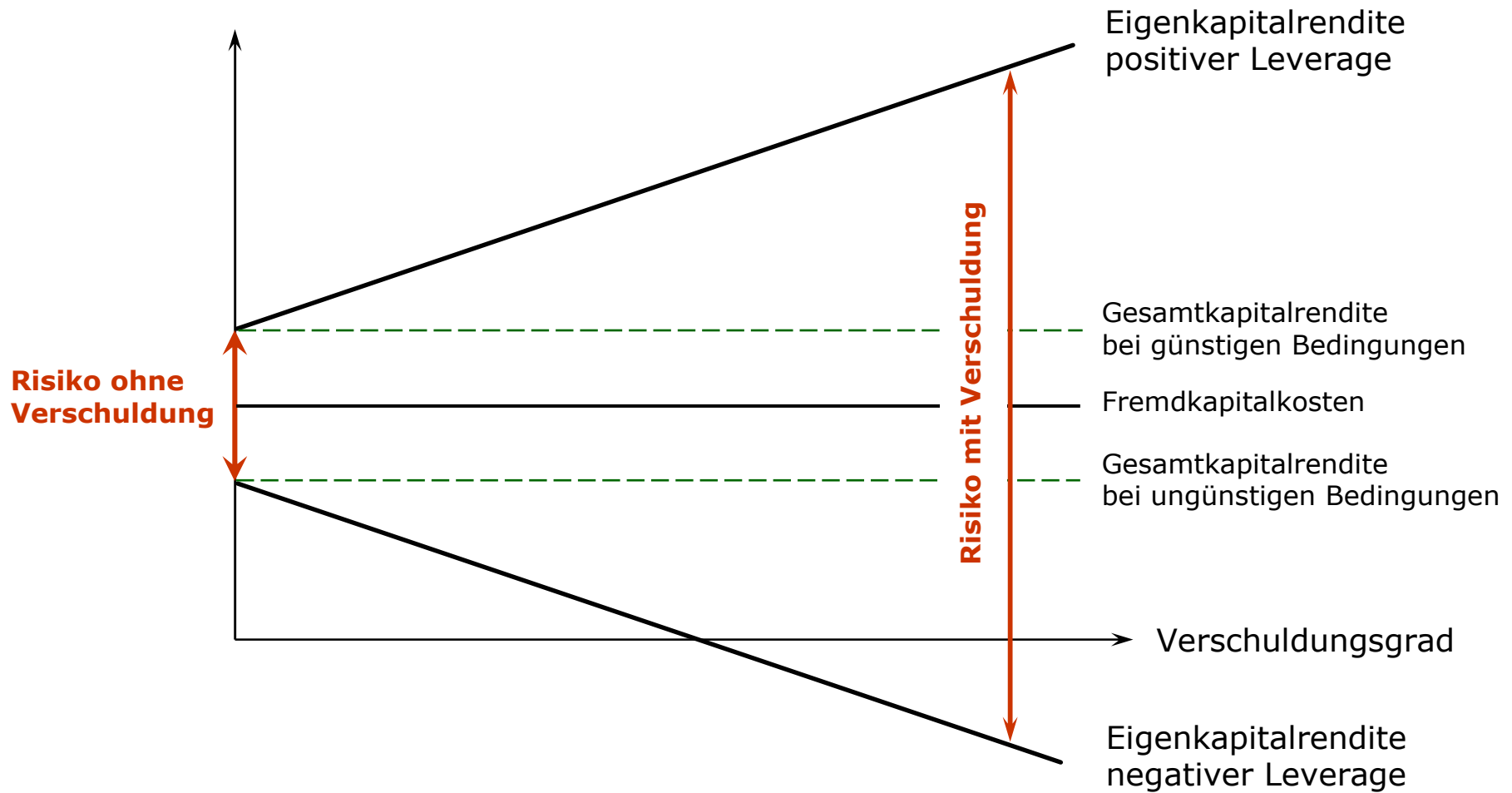
Risk Management strategies

	ex-ante strategies
On farm instruments	<ul style="list-style-type: none"> ■ Liquidity reserves, equity capital ■ Low-risk production activities ■ Diversification ■ Overcapacities, storage ■ Irrigation, (prophylactic) pest management, GMO
Market-based instruments	<ul style="list-style-type: none"> ■ Insurance ■ Sharing of capital ■ Long-term lease contracts, delivery contracts ■ Forward contracts, futures, options
	ex-post strategies
	<ul style="list-style-type: none"> ■ Living standard adjustments ■ Emergency borrowing ■ Distress sales

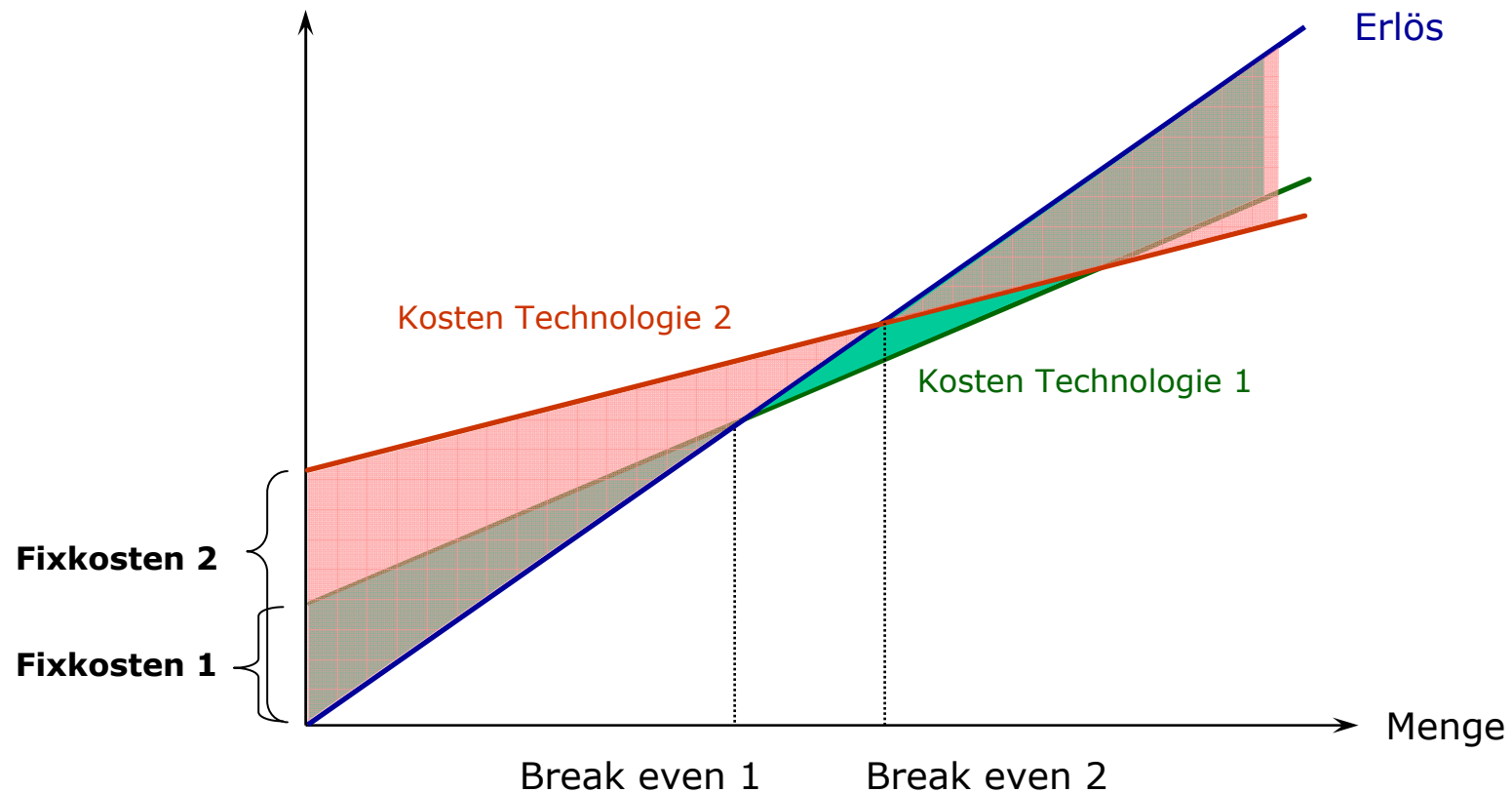
Vor- (+) und Nachteile (-) verschiedener Versicherungstypen

schadensbasierte Versicherungen		indexbasierte Versicherungen	
Einzel-/Mehrfahrenversicherung	Ertragsversicherung	outputbasierte Versicherung	inputbasierte Versicherung
+ garantierte Entschädigungszahlungen	+ garantierte Entschädigungszahlungen	- unsichere Entschädigungszahlungen (Basisrisiko)	- unsichere Entschädigungszahlungen (Basisrisiko)
- nur Absicherung von Extremwetterschäden	+ auch Absicherung von sonstigen Witterungsschäden	+ auch Absicherung von sonstigen Witterungsschäden	+ auch Absicherung von sonstigen Witterungsschäden
- hohe Transaktionskosten	- hohe Transaktionskosten	+/- geringe Transaktionskosten	+ sehr geringe Transaktionskosten
+/- geringe Moral-Hazard-Kosten	- sehr hohe Moral-Hazard-Kosten	+/- geringe Moral-Hazard-Kosten	+ kein Moral-Hazard-Risiko

Financial Leverage



Operating Leverage



⇒ höhere Fixkosten: höhere Sensitivität des Gewinns in Bezug auf Menge / Absatzschwankungen

Kennzahlen zu Agrarpreisen in Deutschland (1993-2008)

Preise pflanzlicher Produkte	Weizen	Gerste	Raps
Beobachtungen	192	192	192
Einheit	€/t	€/t	€/t
Arithmetischer Mittelwert	133,66	148,37	223,72
Standardabweichung	31,24	39,97	56,97
Minimum	93,38	101,31	146,73
Maximum	265,87	301,93	453,83
ADF-Test, Ablehnung H0 (Nichtstationarität)	nein	nein	nein
KPSS-Test, Ablehnung H0 (Stationarität)	ja	ja	ja

Kennzahlen zu Agrarpreisen in Deutschland (1993-2008)

Preise tierischer Produkte	Milch	Schwein	Rind
Beobachtungen	192	192	192
Einheit	Cent/kg	€/kg SG	€/kg SG
Arithmetischer Mittelwert	29,29	2,71	1,38
Standardabweichung	2,66	0,29	0,21
Minimum	26,23	1,77	0,79
Maximum	41,30	3,35	2,07
ADF-Test, Ablehnung H0 (Nichtstationarität)	ja	ja	nein
KPSS-Test, Ablehnung H0 (Stationarität)	nein	nein	ja

Ergebnisse der GARCH-Modellierung

Ljung-Box-Pierce Q-Test der (quadrierten) AR(I)MA-Residuen						
* Lag-Niveau 10,15,20	Ljung-Box-Pierce Q-Test				Engle' s ARCH	
	Residuen		Quadrierte Residuen		Residuen	
Reihe	H*	p-Wert	H*	p-Wert	H*	p-Wert
Weizen	0	0.8679	1	0.0002	1	0.0021
	0	0.8100	1	0.0015	1	0.0251
	0	0.9414	1	0.0110	0	0.1304
Gerste	0	0.8881	0	0.0640	0	0.1576
	0	0.8269	1	0.0036	0	0.0939
	0	0.6511	1	0.0172	0	0.2381
Raps	0	0.1540	0	0.1232	0	0.0903
	0	0.1935	0	0.3043	0	0.2378
	0	0.2997	0	0.4265	0	0.5079
Milch	0	0.5512	1	0.0430	0	0.2817
	0	0.3589	0	0.0791	0	0.4812
	0	0.5090	0	0.2496	0	0.8203
Schwein	0	0.3377	0	0.0874	0	0.1248
	0	0.4426	0	0.1621	0	0.2623
	0	0.6029	0	0.2261	0	0.4831
Rind	0	0.5603	1	0.0470	0	0.1444
	0	0.4371	0	0.1949	0	0.4435
	0	0.6272	0	0.4115	0	0.7758
GARCH(1,1) Modell-Parameter Weizenpreis			$\sigma_t^2 = 0,00058025 + 0,56278 \cdot \varepsilon_{t-1}^2 + 0,053972 \cdot \sigma_{t-1}^2$			

Parameter	Wert	Standard-Fehler	T-Statistik
C	0,00089937	0,0022636	0,3973
K	0,00058025	9,6434e-005	6,0171
GARCH(1)	0,053972	0,089247	0,6047
ARCH(1)	0,56278	0,13555	4,1518

Johansen cointegration test for agricultural prices in European countries

Price (monthly)	Wheat	Barley	Rape	Cattle
Period	1976-2004	1976-2004	1996-2004	1985-2003
Country	UK Spain	UK Spain	Denmark Sweden	Germany France
Hypotheses	LR test statistic (p-Wert)			
0	13,21 (0,3550)	24,91 (0,0092)	19,84 (0,0055)	38,75 (0,0000)
1	4,93 (0,3020)	4,36 (0,3730)	5,05 (0,2876)	7,52 (0,1036)