ÖSTERREICHISCHES INSTITUT
FÜR WIRTSCHAFTSFORSCHUNG

Potential Capital Requirement for a Minimum Price Insurance Scheme

Wheat, Maize, Rape Seed

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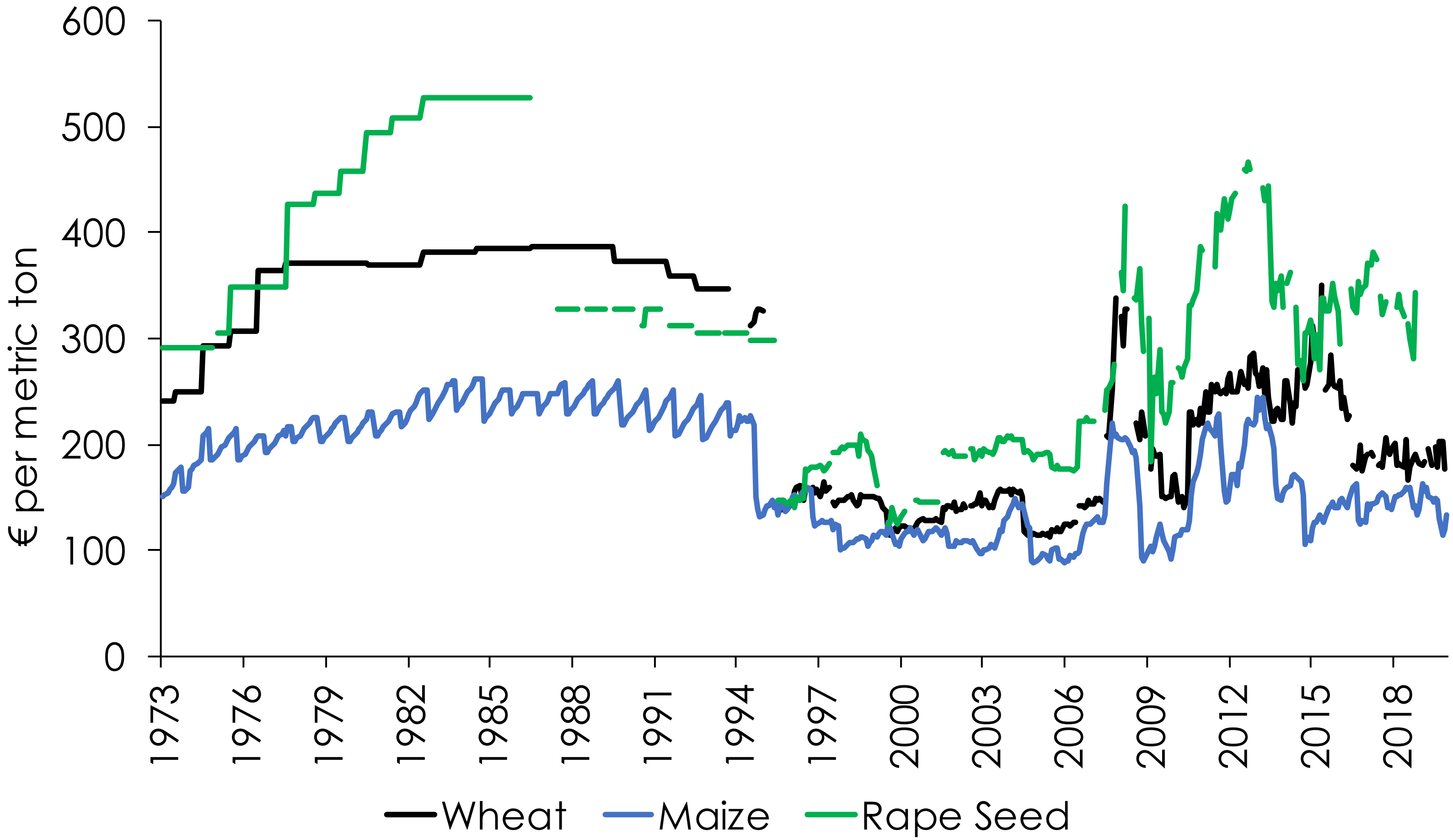
Motivation

- Common Agricultural Policy introduced administrative prices for crops in 1967
- CAP-administrative prices first lowered in 1992
- Since 2005 administrative prices below market prices
- Prices fluctuate more widely after 2007
- Consequently farmer's income is more exposed to price risk

WIFO-Working Paper No. 601/2020: https://www.wifo.ac.at/publikationen/working_papers?detail-view=yes&publikation_id=65928.

Monthly producer prices for premium wheat, maize, and rape seed in Austria, 1973-2019



S: Statistics Austria.

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Design of the insurance product

- Insurance contract must be signed on the last working day in January, at the latest
- Contract duration for wheat/maize is 9 months
- Contract duration for rape seed is 6 months
- Insured Minimum price for
  - wheat/maize is compared to spot price as of the first trading day in November
  - rape seed is compared to market price on the first trading day in August
- Claims payment occurs if spot price < minimum price

Premium Calculation for the Minimum Price Insurance

Application of the option pricing model for European put by Bardsley - Cashin (1990):

$$P_t = S_t(\Phi(I_1) - 1) - Ke^{-r(T-t)}(\Phi(I_2) - 1)$$

with

$$I_1 = log\left(\frac{S_t}{Ke^{-r(T-t)}}\right)\frac{1}{\sigma\sqrt{(T-t)}} + 0.5\sigma^2\sqrt{(T-t)}$$

$$I_2 = I_1 - \sigma\sqrt{(T-t)}$$

where P=option price, S=current spot price, K=strike price, σ^2=one period variance of log returns, r= risk free interest rate, (T-t)=time to maturity, Φ(.)=cumulative normal distribution function.

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Premium Calculation for the Minimum Price Insurance

We apply a Bayesian normal linear stochastic volatility model with autoregressive stochastic volatility (Kastner, 2016) to demeaned log returns of nearby futures prices $y_t = \log(F_t) - \log(F_{t-1})$: :

$$y_t = N\left(0, e^{h_t}\right)$$

$$h_\mathrm{t} | h_{\mathrm{t}-1}, \mu, \phi, \sigma_\eta = \mathrm{N}\left(\mu + \phi(h_{\mathrm{t}-1} - \mu), \sigma_\eta^2\right),$$

$$h_0 | \mu, \phi, \sigma_\eta = \mathrm{N}\left(\mu, \frac{\sigma_\eta^2}{(1 - \phi^2)}\right)$$

where $N\left(\mu, \sigma_\eta^2\right)$ denotes the normal distribution with mean μ and variance σ_η^2, and h_t represents the unobserved time-varying autoregressive process of order one for the one period volatility of log returns (variance process).

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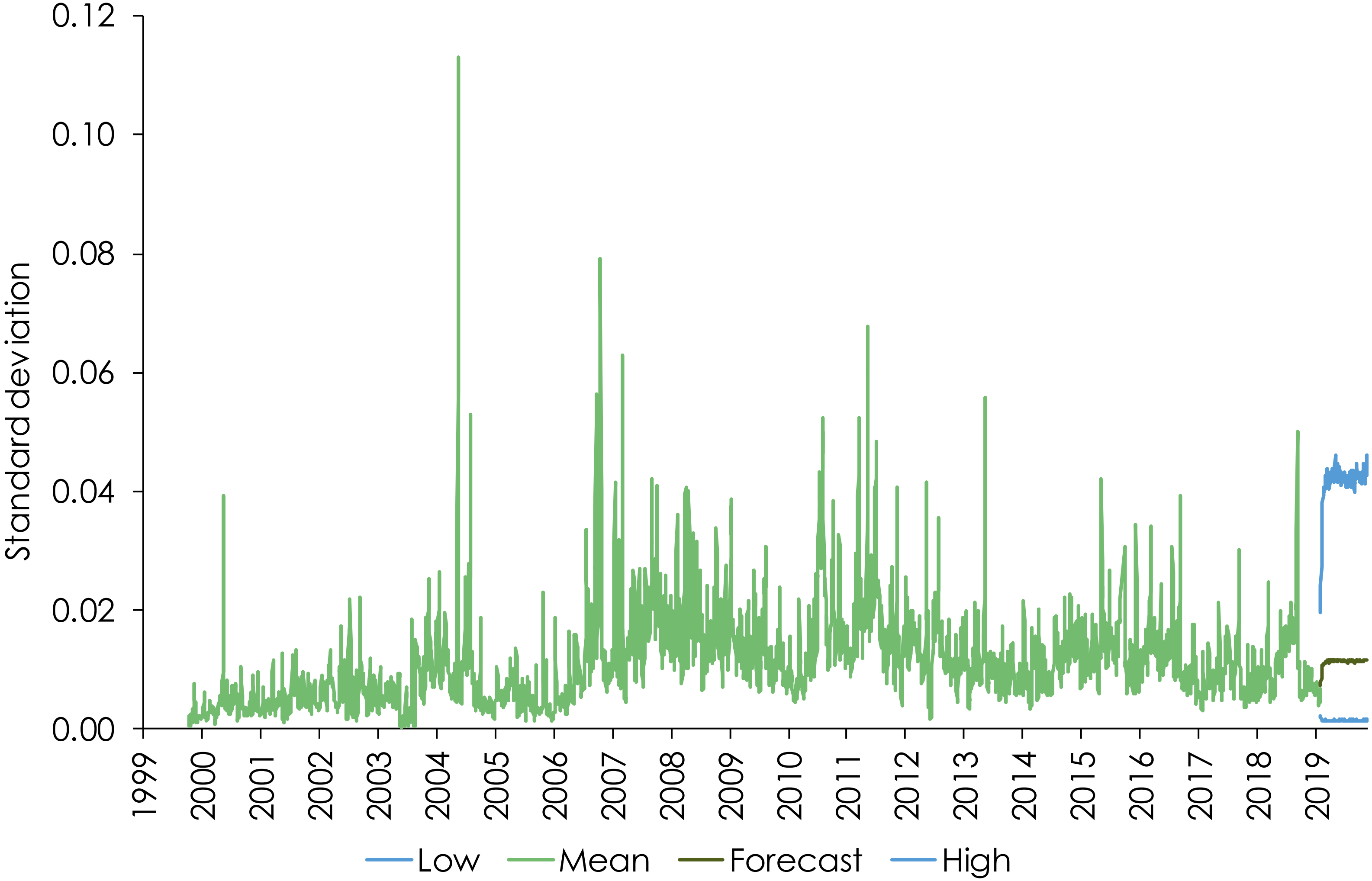
Historic and forecasted volatility of log returns for wheat nearby futures process, 9 months horizon



S: MATIF. Standard deviation estimated from 10,000 forecasts of the volatility based on Bayesian normal linear model with AR(1) stochastic volatility using R-package stochvol (Kastner, 2016). Low and High provide 5 and 95 percent confidence intervals from 10.000 draws.

Level of insurance premium based on Black option price formula for selected insured minimum prices

Wheat	Maize	Rape seed	Wheat	Maize	Rape seed
Insured minimum prices € per metric ton			Premium lev el € per metric ton		
130	110	240	0.55	0.05	0.00
140	120	260	1.28	0.22	0.04
150	130	290	2.59	0.67	0.53
160	140	310	4.69	1.70	1.87
170	150	330	7.73	3.58	5.05
180	160	350	11.78	6.60	11.01
190	170	370	16.87	10.89	20.33

S: Black (1976) option price formula using the median forecasted standard deviation at maturity T based on 10,000 forecasts of the volatility from a Bayesian normal linear model with AR(1) stochastic volatility using R-package stochvol (Kastner, 2016). Insured period for wheat and maize 9 months, and 6 months for rape seed starting with February 1st 2019. The realised nearby futures prices on January 31st 2019 were wheat (€ 204.25), maize(€ 177.75), and rape seed(€ 372).

Profit and loss distribution for bundles of crops

Insured minimum price level			Lower quantiles of the profit/loss distribution						Mean profit of insured bundle
Wheat	Maize	Rape seed	0.01%	0.10%	1%	5%	10%	25%	
€ per metric ton			€ per insured bundle						
130	110	240	-1,003.19	-752.58	-266.99	6.94	6.94	6.94	-0.83
140	120	260	-1,159.75	-912.33	-401.37	-68.89	17.95	17.95	2.67
150	130	290	-1,316.60	-1,044.08	-525.05	-182.76	-32.31	41.10	10.92
160	140	310	-1,468.14	-1,181.42	-634.20	-286.15	-129.03	71.27	26.42
170	150	330	-1,577.84	-1,291.08	-742.88	-384.12	-217.96	36.58	50.54
180	160	350	-1,653.31	-1,413.92	-869.66	-467.08	-294.37	-17.55	82.09
190	170	370	-1,705.33	-1,486.52	-974.31	-564.30	-355.62	-55.80	118.06

S: Own computations based on 10,000 simulated accumulated return paths using the Bayesian linear normal model for each crop. The insured bundle covers 11 metric tons of wheat, 18 metric tons of maize, and 1 metric ton of rape seed at the insured minimum prices per metric ton given in columns 1 to 3. Profits result from the premium income for the insured bundle based on insurance premium shown in Table 2 and losses result from payouts for the insured bundle if the forecasted price level at maturity T is below the insured minimum price. The 1% quantile of the loss distribution provides the information that a loss of this size or bigger occurs once every 100 years.

Conclusions

- Conjoint analysis by KeyQuest found that there is potential demand for insuring about 78% of the wheat harvest in Austria.
  - 12% of farmers would prefer the lowest insured prices of 130 €
  - 29% prefer 150 €
  - 9% prefer 190 €
- Estimated market volume for crop insurance: 9.5 mn €
- Premium levels provided here are net of transaction costs, costs of equity and taxes
- Minimum price insurance appears viable and can be implemented throughout Europe