The role of uncertainty in assessing agricultural responses to food security and climate change: A Case Study from Norway

Klaus Mittenzwei

MACSUR TradeM Workshop
Nov 25-27, 2014, Hurdalsjøen, Norway

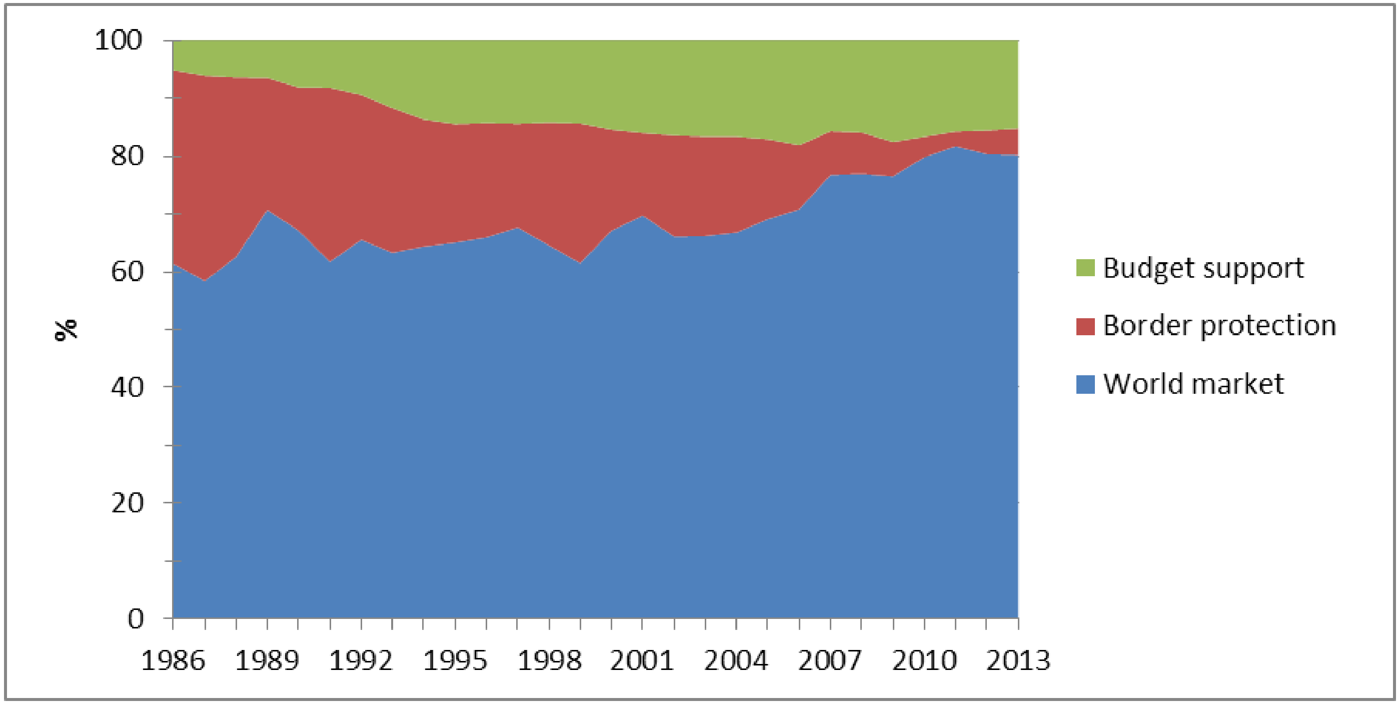
NILF
Norsk institutt for
landbruksøkonomisk f

Background and motivation

- Farmers make decisions under uncertainty
  - Crop planting and management decisions differ in time from sale of harvest
  - High dependency of farm income on ag policies in Norway
    - Subsidy rates may change due to policy reform

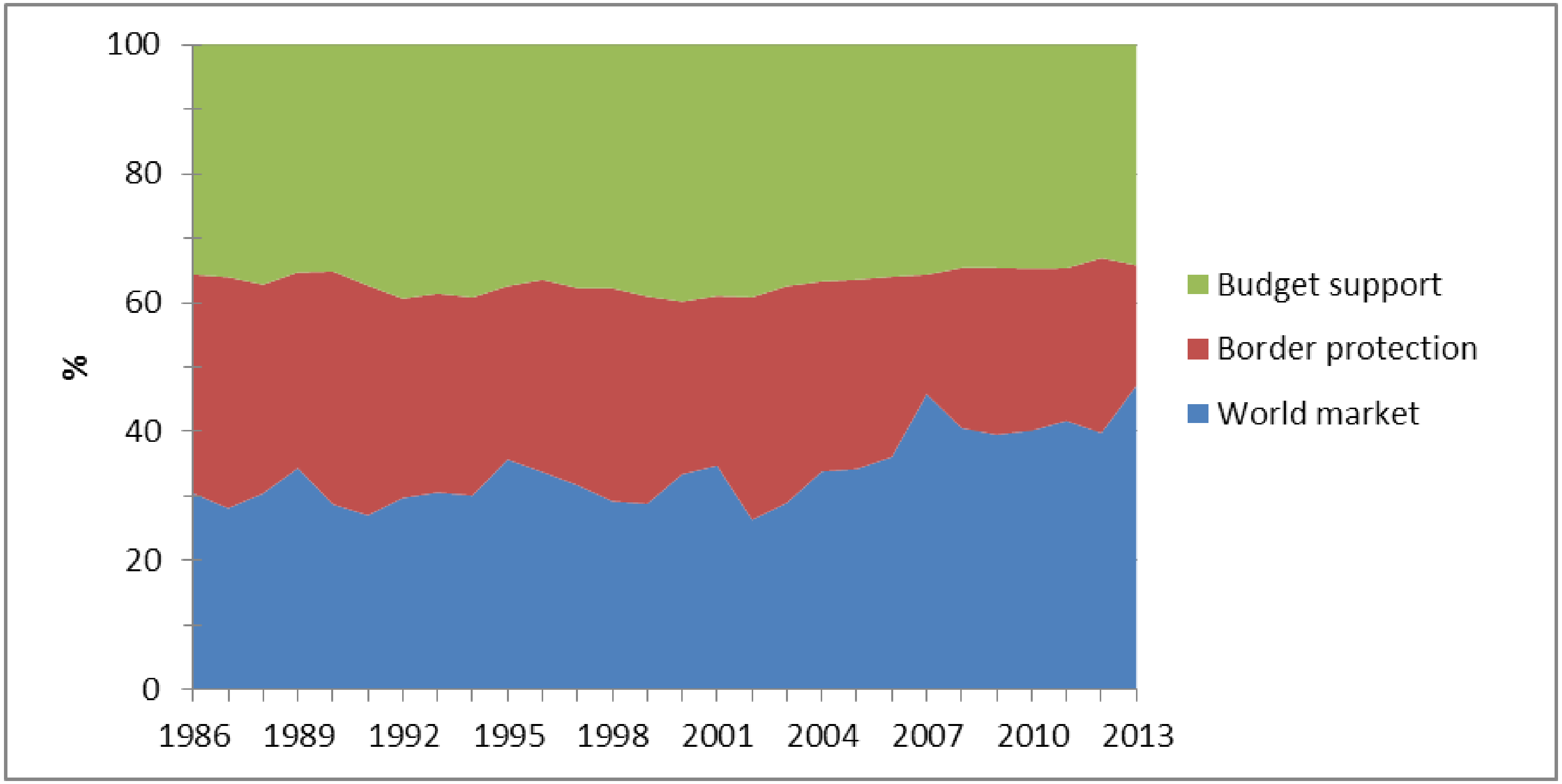
- Approach
  - Stochastic regional farm-specific module
    - Standard mean-variance model
  - Stochastic scenario method
    - Run numerous simulations where economic agents make some decisions under uncertainty in an otherwise deterministic environment

Potential for policy uncertainty: Gross farm revenues in EU-27 (1986-2013)



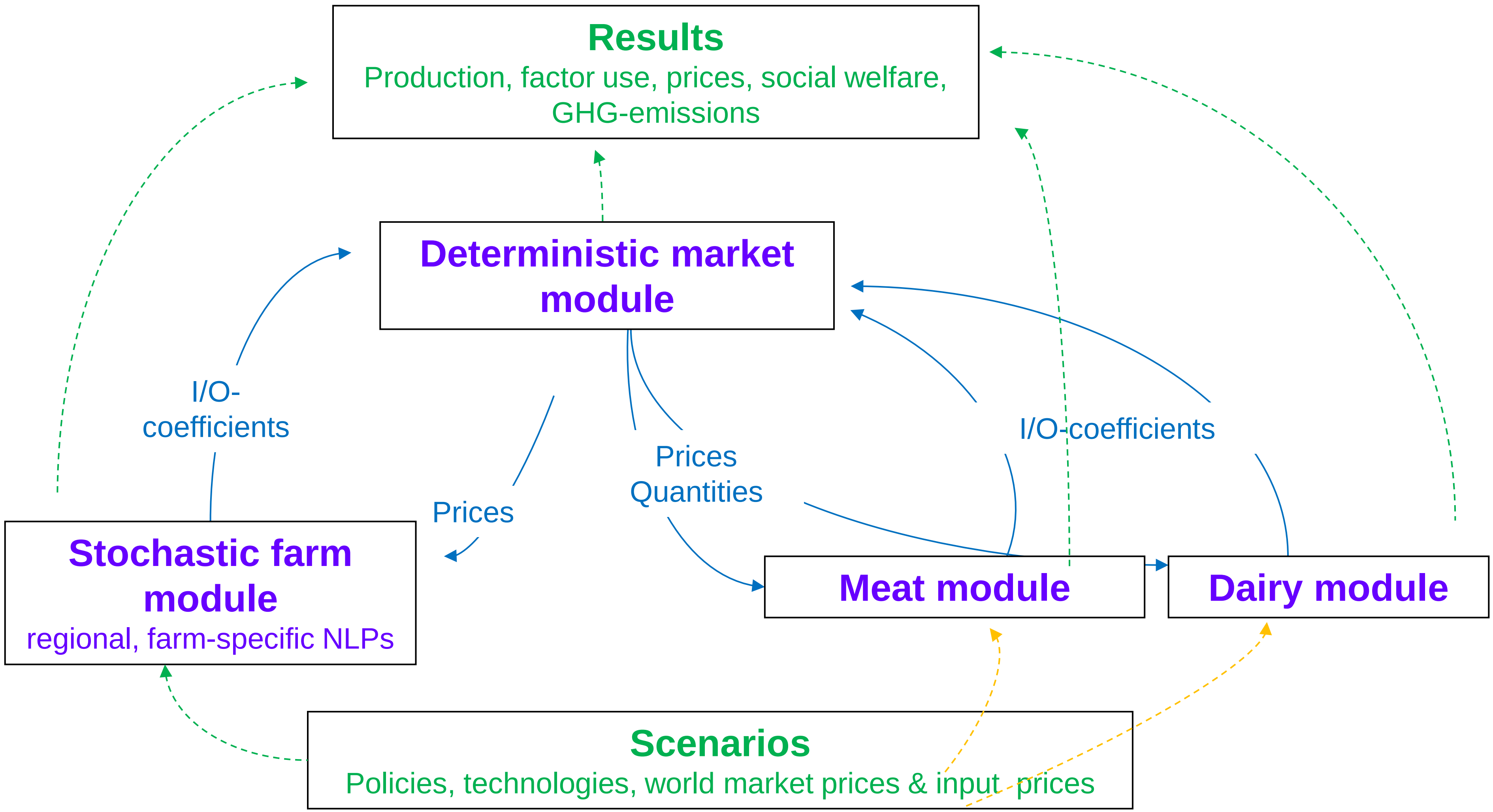
Source: OECD (2014)

Potential for policy uncertainty: Gross farm revenues in Norway (1986-2013)



Source: OECD (2014)

Sector model



NILF
Norsk institutt for landbruksøkonomisk forskning

Stochastic farm module

- Timing
  - (Risk-avers) farmers make crop planting decisions (activity level and N-intensity) under uncertainty regarding yields and payment rates:
    $$E(U|\theta,\vartheta) \equiv \max_{\boldsymbol{y},\boldsymbol{x}} M\big(PS(\boldsymbol{y},\boldsymbol{x}|\boldsymbol{p},\boldsymbol{w},\theta,\vartheta)\big) - \sigma \cdot V\big(PS(\boldsymbol{y},\boldsymbol{x}|\boldsymbol{p},\boldsymbol{w},\theta,\vartheta)\big).$$
  - Nature resolves uncertainty. Farmers adjust animal production system given revealed yields and payment rates.
  - Farmers adjust animal production system given crop levels and N-intensity:
    $$E(U|\theta^n,\vartheta^n) \equiv \max_{\boldsymbol{x}} M\big(PS(\boldsymbol{x}|\boldsymbol{y},\boldsymbol{p},\boldsymbol{w},\theta^n,\vartheta^n)\big) - \sigma \cdot V\big(PS(\boldsymbol{x}|\boldsymbol{y},\boldsymbol{p},\boldsymbol{w},\theta^n,\vartheta^n)\big)$$

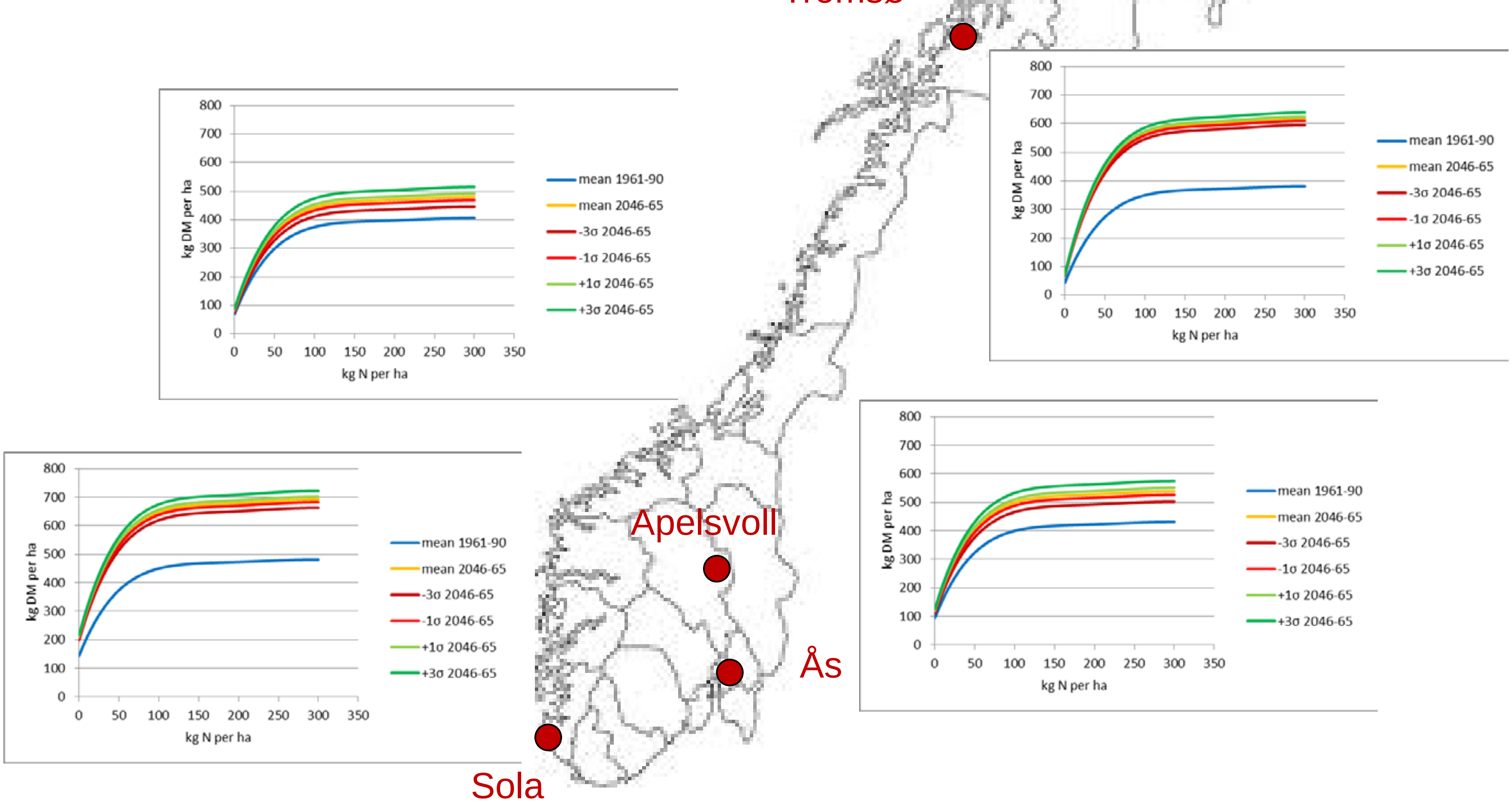
- $\boldsymbol{p}: vector\ of\ exogenous\ output\ prices$
- $\boldsymbol{w}: vector\ of\ exogenous\ input\ prices$
- $\boldsymbol{y}: vector\ of crop\ activity\ levels\ and\ N - intensities$
- $\boldsymbol{x}: vector\ of non - crop\ activity\ levels$
- $\theta: stochastic\ weather\ variable\ with$ $discrete\ distribution\ \tau_n: \tau_1, \ldots, \tau_N\ and\ probabilities\ q_n: q_1, \ldots, q_N$
- $\vartheta: stochastic\ policy\ variable\ with$ $discrete\ distribution\ \sigma_n: \sigma_1, \ldots, \sigma_N\ and\ probabilities\ \rho_n: \rho_1, \ldots, \rho_N$

Deterministic market module

- Run $N \times N$ simulations for $\tau_1, \ldots, \tau_N \times \rho_1, \ldots, \rho_N$
- Receive "pseudo-stochastic" distribution of W: $\mathrm{W}(\boldsymbol{x}|\boldsymbol{y}^{\theta_1 \vartheta_1}, \boldsymbol{p}, \boldsymbol{w}, \boldsymbol{b}), \ldots, \mathrm{W}(\boldsymbol{x}|\boldsymbol{y}^{\theta_N \vartheta_N}, \boldsymbol{p}, \boldsymbol{w}, \boldsymbol{b})$

- $\boldsymbol{p}$: *vector of exogenous output prices*
- $\boldsymbol{w}$: *vector of exogenous input prices*
- $\boldsymbol{y}$: *vector of crop levels and N − intensities*
- $\boldsymbol{x}$: *vector of non − crop levels*
- θ: *stochastic weather variable with discrete distribution* $\tau_n: \tau_1, \ldots, \tau_N$ *and probabilities* $q_n: q_1, \ldots, q_N$
- ϑ: *stochastic policy variable with discrete distribution* $\sigma_n: \sigma_1, \ldots, \sigma_N$ *and probabilities* $\rho_n: \rho_1, \ldots, \rho_N$

Grassland yields



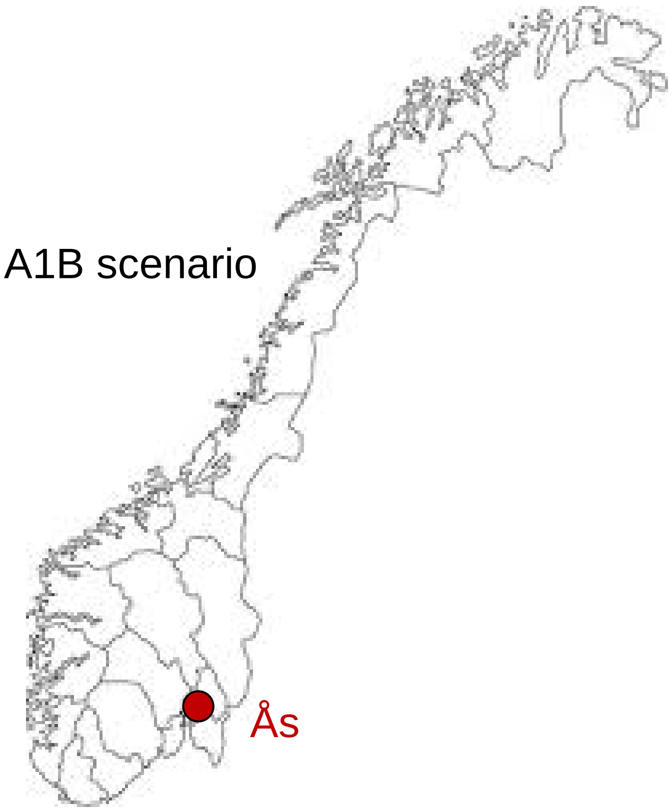
Source: Persson, T. and Höglind, M. (2013): «Effect of climate change on harvest security and biomass yield of two timothy ley harvesting systems in Norway». *The Journal of Agricultural Science* 152(2): 205-216

Cereals yields

Rawdata

- 1 crop model (CSM-CERES-wheat)
- Daily weather data generated by 15 global climate models A1B scenario
- 4 sets of representative soil profiles with various size
- 3 wheat varieties (Bjarne, Demonstrant, Zebra)
- 1 planting date
- 1 N-fertilizer level

kg/ha	Baseline	Simulation	Applied factor
Mean	**5 133**	5 724	
Variance	437 388	525 883	
Std.deviation	661	725	
MIN3	3 149	**3 548**	0.6913
MIN1	4 472	**4 999**	0.9739
MEAN	5 133	**5 724**	1.1151
PLUS1	5 794	**6 449**	1.2564
PLUS3	7 117	**7 899**	1.5390



Source: Persson, T. and Kværnø, M (2014): Impact of soil properties regionalization methods on regional wheat yield in souteastern Norway. MACSUR Mid-term conference, April 1-4, Sassari, Italy

Policy uncertainty

The rates for all payments vary within a range of +/- 5 per cent.

	Applied factor
MIN3	0.950
MIN1	0.975
MEAN	1.000
PLUS1	1.025
PLUS3	1.050

Results

– Dairy farm, Southern Norway, farmed land (ha)

Yield/Policy	MIN3	MIN1	MEAN	PLUS1	PLUS3	Difference MIN3-PLUS3
MIN3	33.012	33.012	33.325	33.325	33.325	*0.313*
MIN1	32.138	32.138	32.446	32.446	32.446	*0.308*
MEAN	31.720	31.720	32.026	32.026	32.026	*0.306*
PLUS1	31.315	31.315	31.619	31.619	31.619	*0.304*
PLUS3	30.540	30.540	30.839	30.839	30.839	*0.300*
Difference MIN3-PLUS3	*2.472*	*2.472*	*2.486*	*2.486*	*2.486*	

Results

– Dairy farm, Northern Norway, farmed land (ha)

Yield/Policy	MIN3	MIN1	MEAN	PLUS1	PLUS3	Difference MIN3-PLUS3
MIN3	51.282	52.062	52.830	53.587	54.334	*3.052*
MIN1	50.059	50.813	51.556	52.288	53.009	*2.951*
MEAN	49.469	50.210	50.941	51.661	52.371	*2.902*
PLUS1	48.892	49.621	50.340	51.048	51.747	*2.855*
PLUS3	47.777	48.483	49.179	49.866	50.543	*2.766*
Difference MIN3-PLUS3	*3.505*	*3.579*	*3.651*	*3.722*	*3.791*	

Results

Milk production (mill ltr)

Yield/Policy	MIN3	MEAN	PLUS3
MIN3	1475		
MEAN		1508	1508
PLUS3		1508	1508

Dairy cows (1 000 heads)

Yield/Policy	MIN3	MEAN	PLUS3
MIN3	228		
MEAN		231	232
PLUS3		235	235

Milk price (kg per ltr milk)

Yield/Policy	MIN3	MEAN	PLUS3
MIN3	4.41		
MEAN		4.39	4.39
PLUS3		4.38	4.38

Adult sheep (1 000 heads)

Yield/Policy	MIN3	MEAN	PLUS3
MIN3	725		
MEAN		775	788
PLUS3		862	835

Fodder area (mill ha)

Yield/Policy	MIN3	MEAN	PLUS3
MIN3	452		
MEAN		455	457
PLUS3		482	485

Discussion

- Introducing uncertainty in the sector model adds considerable complexity
- Policy uncertainty more important than climate uncertainty?
- Next steps
  - other sources of uncertainty?
    - => account for world market price volatility due to climate change outside Norway
  - timing and adjustment of farmer's response to the resolution of uncertainty is very simplistic
    - => more frequent interplay between Nature and farm decision making
    - => more adjustment options