

PROTEIN₂.



The Future of Food?



The cultured protein transition: Effects on Norwegian agriculture

7.12.2022 Klaus Mittenzwei

Outline

- Research question and main assumptions
- Scenarios
- Model
- Results
- Discussion and conclusion

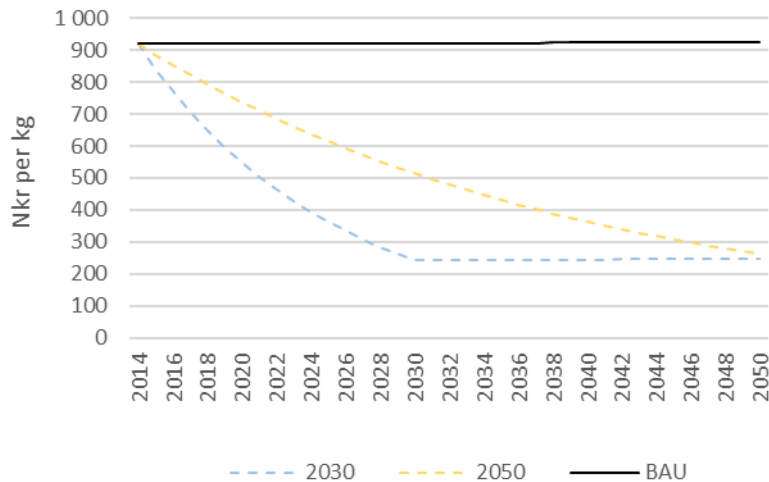
Research question and main assumptions

- Research question
 - To model how protein substitution might disrupt the Norwegian food value chain, identify where in the value chain effects will be experienced and the environmental impact of these changes
- Main assumption: Three key drivers of the cultivated protein transition
 1. The (relative) price of the cultured food products
 2. The potential production volume
 3. The substitution possibilities with conventional, animal-based protein

Driver 1: The (relative) price of the cultured food products

- Price for cultured meat taken from Vergeer et al. (2021)
- 80% of the price difference between cultured food products and conventional food product in the base year 2014 is cut by 2030 or 2050 (i.e., 16 og 36 years of technological development)
- Further assumption: Cultured dairy product follows the cultured meat product

Consumer price of cultured dairy product



Consumer price of cultured meat product

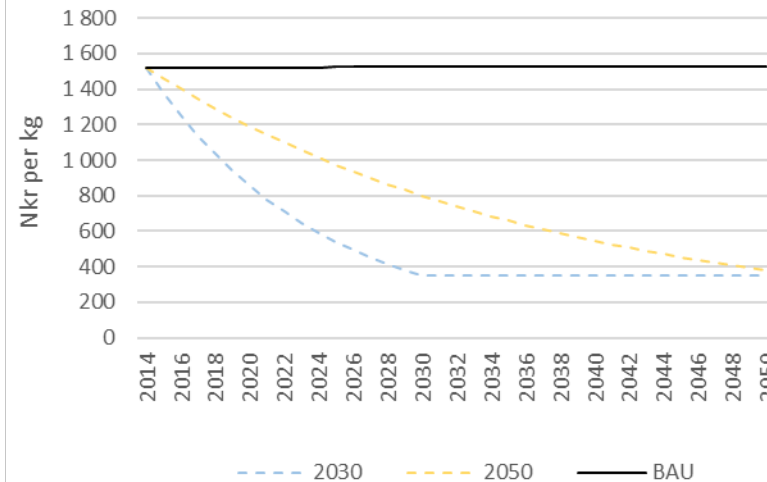
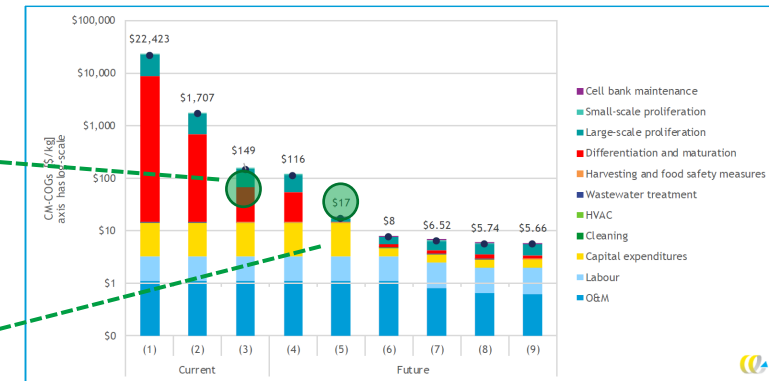


Figure 4 - COGS model of CM (\$/kg CM), overview of scenarios (log-scale)¹²



Source: Vergeer et al. 2021. TEA of cultivated meat. Future projections of different scenarios. Report 190254. CE Delft.

Driver 2: The potential production volume

- Norway is a small, open economy
- Cultured food products can be sourced from international or domestic market at given prices in sufficiently large quantities

Driver 3: The substitution possibilities with conventional, animal-based protein

- Substitutes of the cultured meat product
 - Beef
 - Sheep and goat
 - Pork
 - Poultry
- Substitutes of the cultured dairy product
 - Cheese
 - Skim milk powder
- Elasticities calibrated to current and expected future demand to assure consistency
 - Own-price: -0.35
 - Cross-price: +0.3

Source:

Klößner, C.A. et al. 2022. Milk, Meat, and Fish From the Petri Dish – Which Attributes Would Make Cultured Protein (Un)attractive and for Whom? Results from a Nordic Survey. *Frontiers in Sustainable Food Systems*
DOI: <https://doi.org/10.3389/fsufs.2022.847931>

Gustavsen, G.W. and Mittenzwei, K. 2022. Potential demand for synthetic meat. *Proceedings in System Dynamics and Innovation in Food Networks 2022*.
DOI: <https://doi.org/10.18461/pfsd.2022.2204>



Scenarios differ with respect to preference shift to cultured food and speed of technological development starting in 2015

Scenario name	Price alignment with conventional food products	Preference shift
BAU	No	No
2030, 0	2030	No
2030, 1	2030	Medium (1 per cent p.a.)
2030, 2.5	2030	Large (2.5 per cent p.a.)
2050, 0	2050	No
2050, 1	2050	Medium (1 per cent p.a.)
2050, 2.5	2050	Large (2.5 per cent p.a.)

Example of preference shift:
 Per capita beef demand: 20 kg
 1%: -200 g beef / + 200 g cultured meat
 2.5%: -500 g beef / +500 g cultured meat

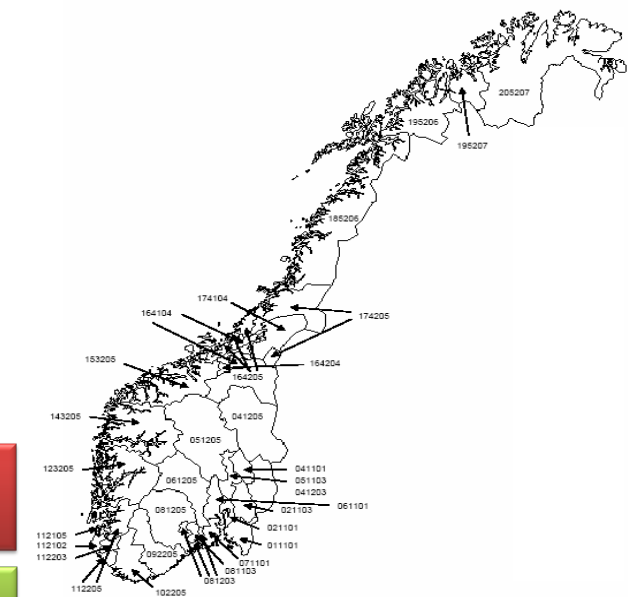
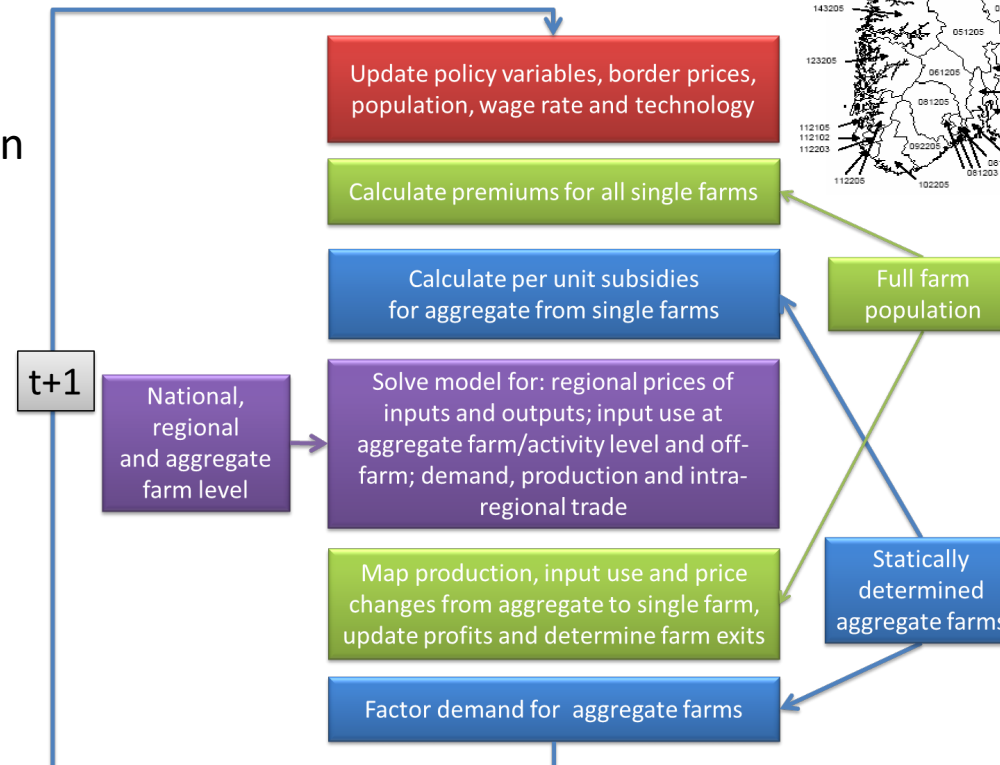
Preference shift:

Exogenous (i.e., unrelated to price) reduction in the per capita consumption of the conventional food substitute which is offset by an equal increase in the demand of cultured protein measured in absolute terms.



Simulation model: Agrispace

- Aim: To simulate the path of adjustment caused by an **exogenous shock** (e.g., policy reform, market introduction of new food products) for agriculture in Norway
- **Dynamic-recursive**: Solves for annual equilibrium starting from base year 2014
- **Spatial** (32 regions): single farms – farm clusters – regions – country – global
- Covers **all farms** applying for subsidies
- Flexible Generalized Leontief Expenditure System
- **Endogenous structural change** in agriculture based on farm income and stochastic income threshold



Source:
Mittenzwei, K. and Britz, W. 2018. Analysing Farm-Specific Payments for Norway using the Agrispace Model
DOI: [10.1111/1477-9552.12268](https://doi.org/10.1111/1477-9552.12268)



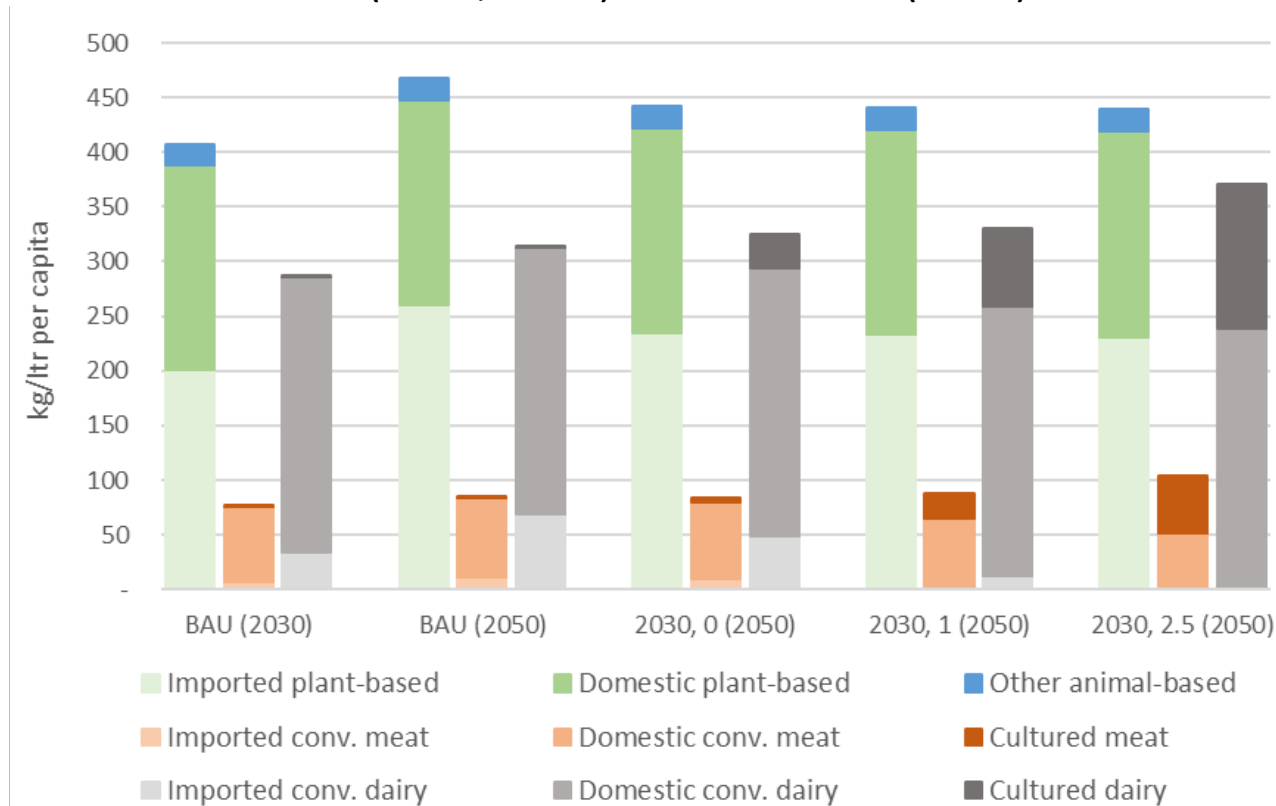
Growth in food demand is not fully met by increased domestic production in the BAU

Market balance in 2014 and 2050 (1000 t, BAU)

	Production	Feed demand	Human consumption	Net imports
2014				
Grains	763	1 123	387	747
Meat	340		360	20
Milk/Dairy	1 524		666	7
2050				
Grains	765	1 270	502	1 007
Meat	440		509	69
Milk/Dairy	1 794		836	57

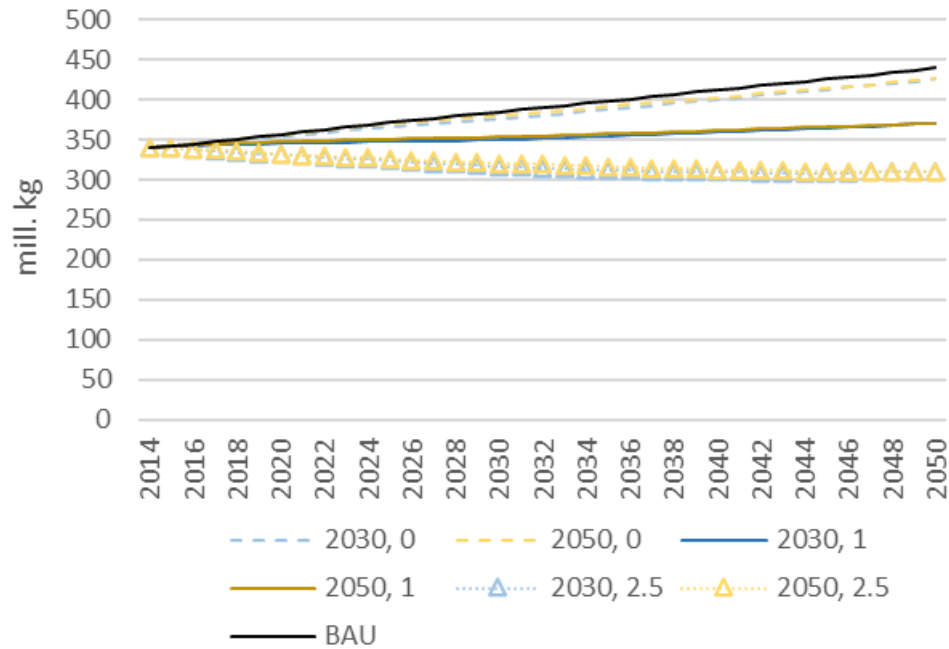
Cultured protein affects the consumption of all food products

Per capita demand by food item and origin for BAU (2030, 2050) and scenarios (2050)

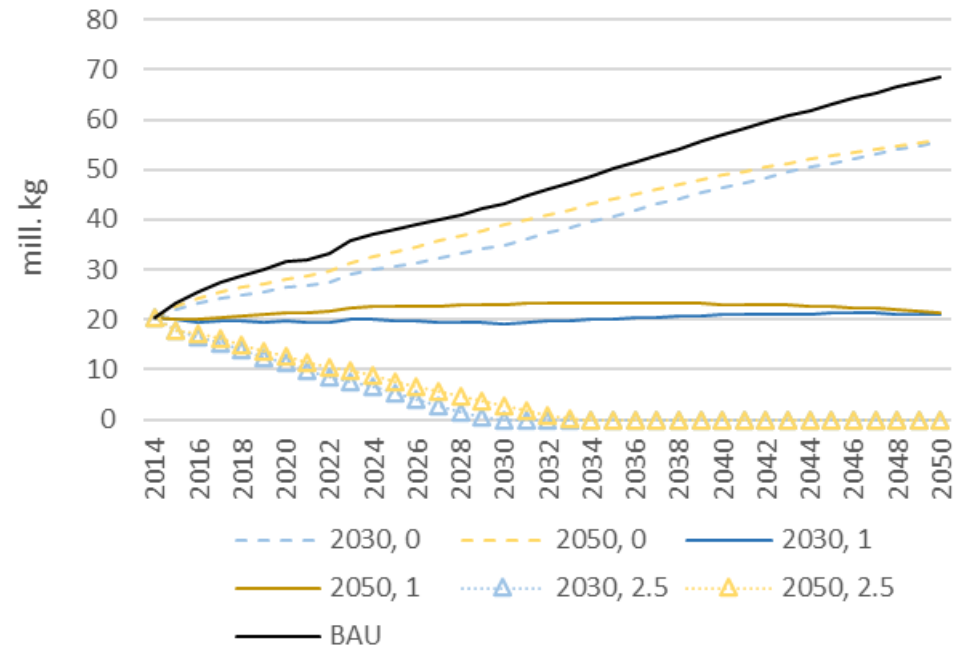


Cultured meat replaces imports, but also domestic production

Meat production

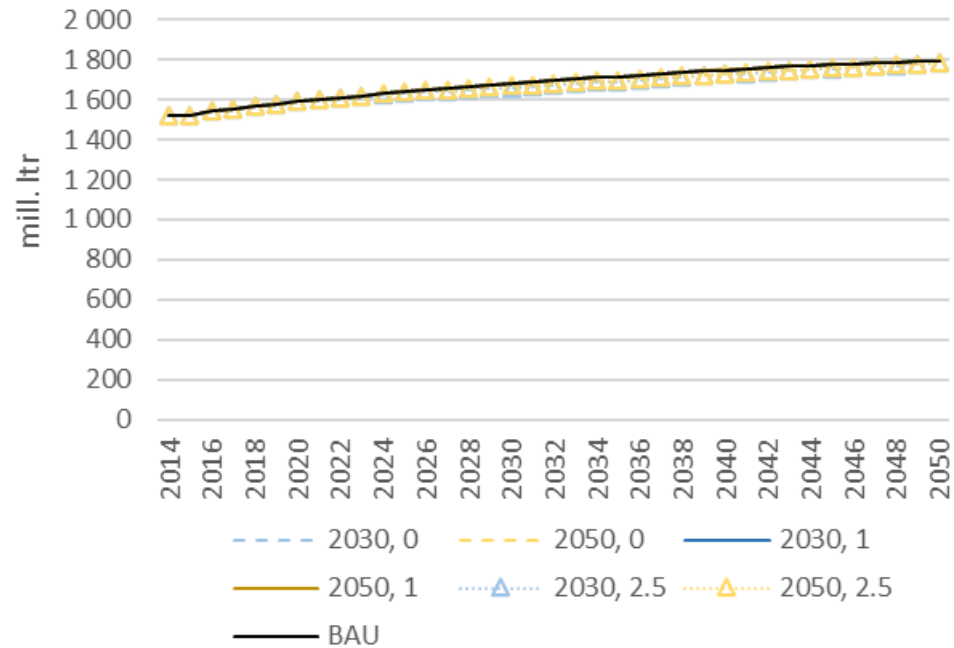


Meat imports

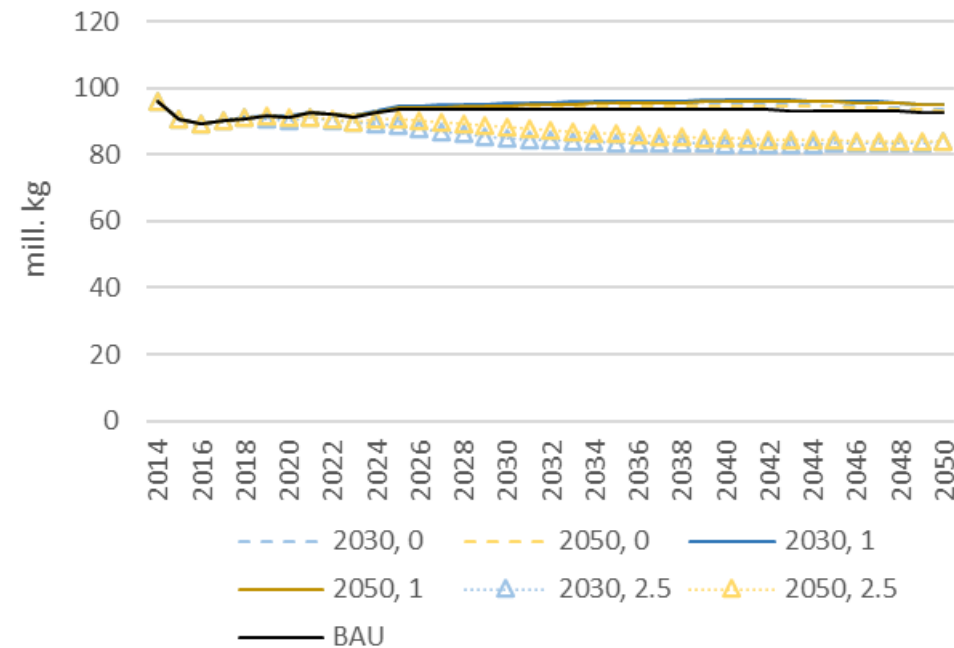


Milk production less hit due to incomplete substitution possibilities (and profitability)

Milk production

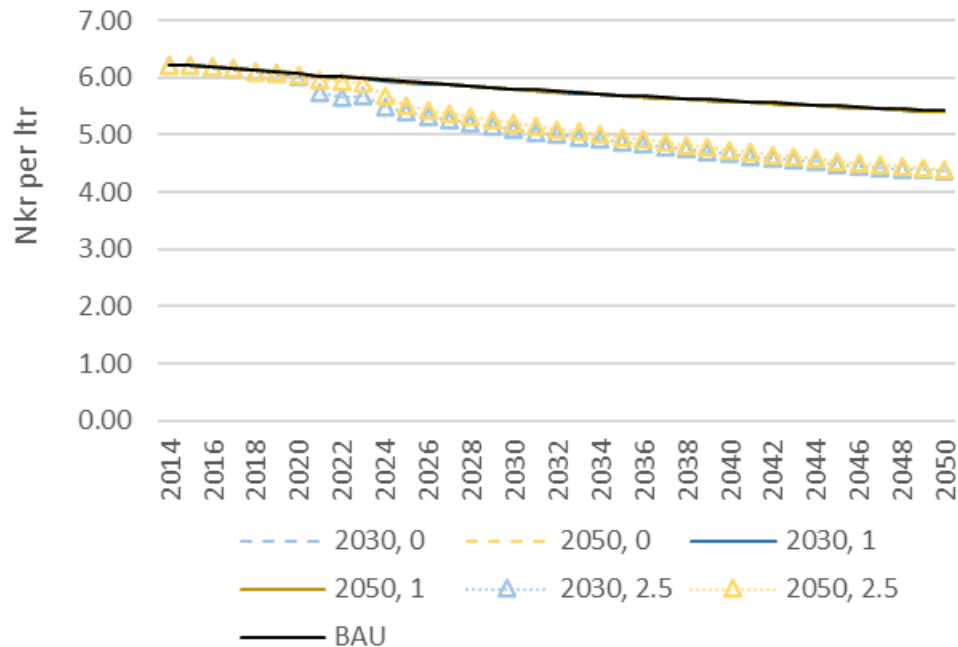


Cheese and skim milk powder production

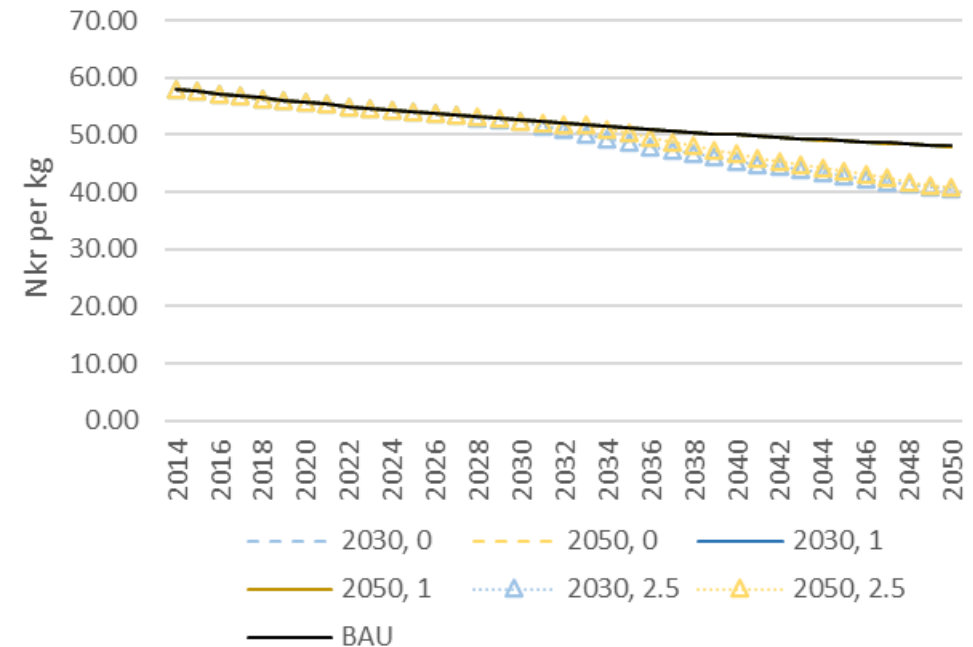


Producer prices drop as a consequence of reduced demand

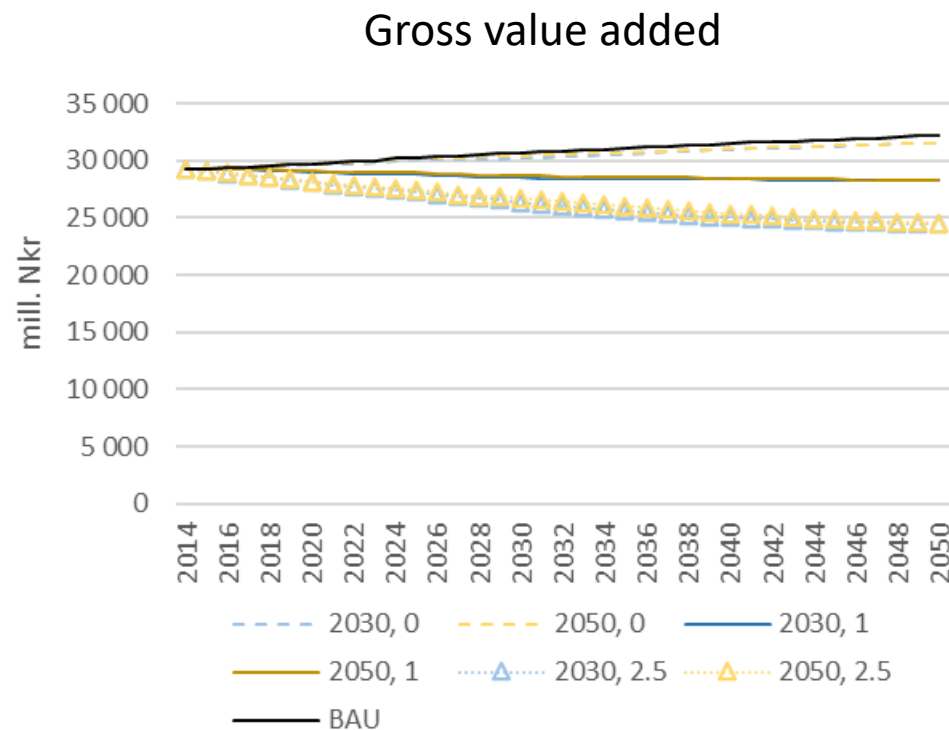
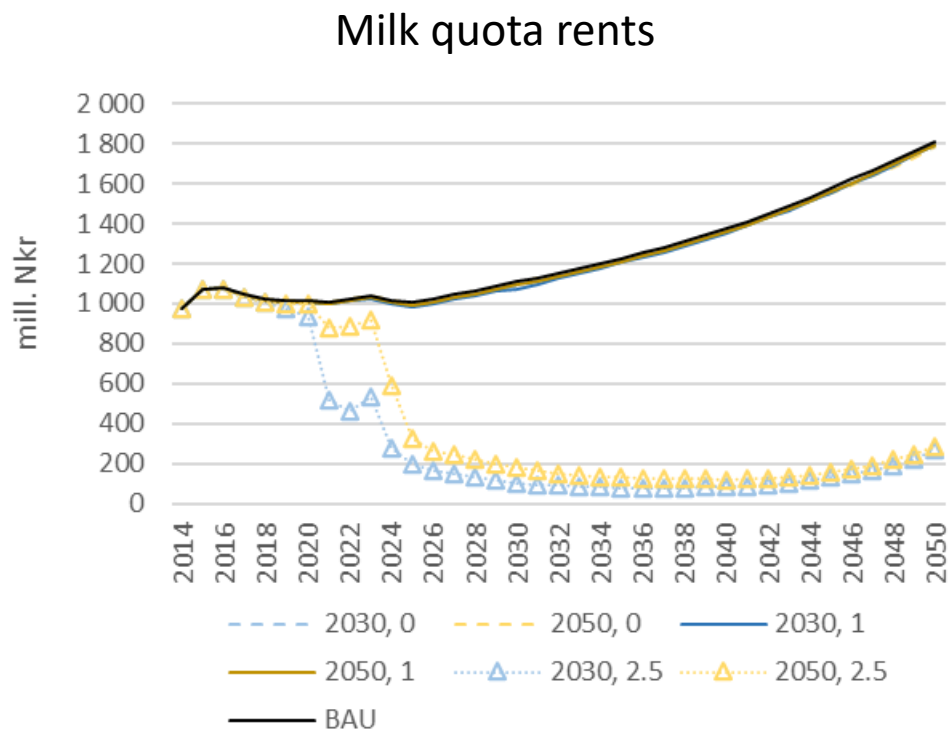
Producer price of milk



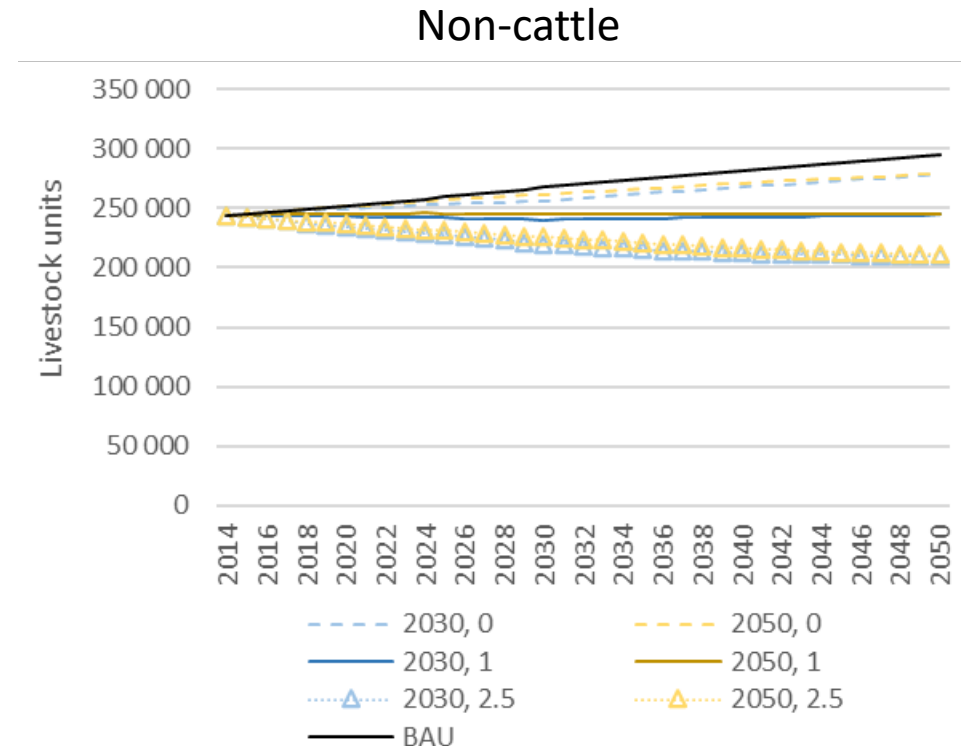
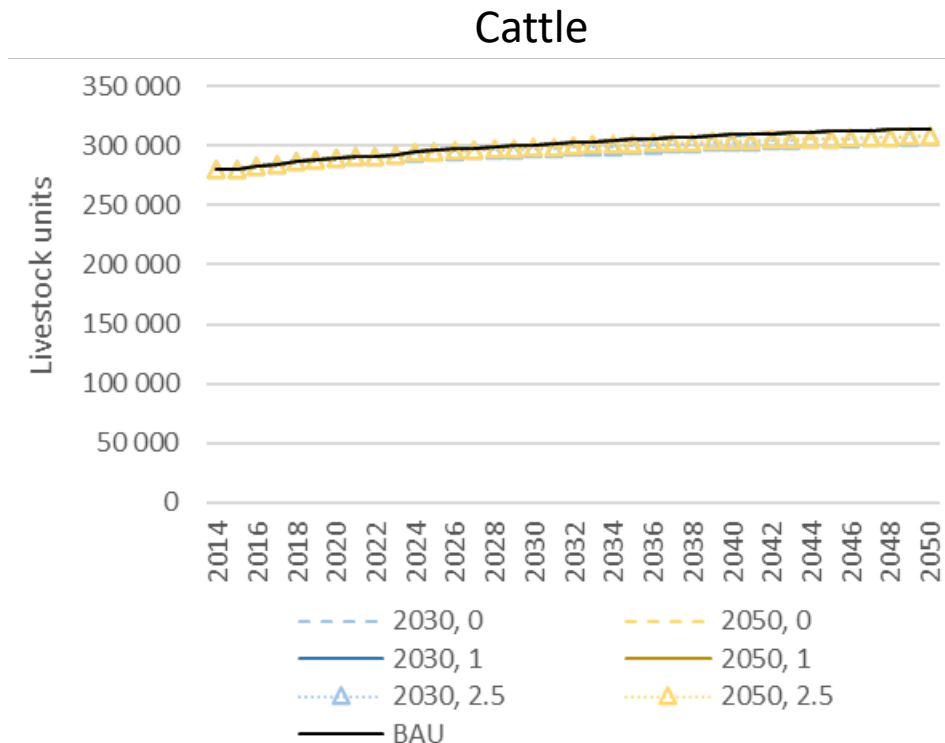
Producer price of beef



Milk quota rents disappear, farm incomes (GVA) fall by up to 25 per cent

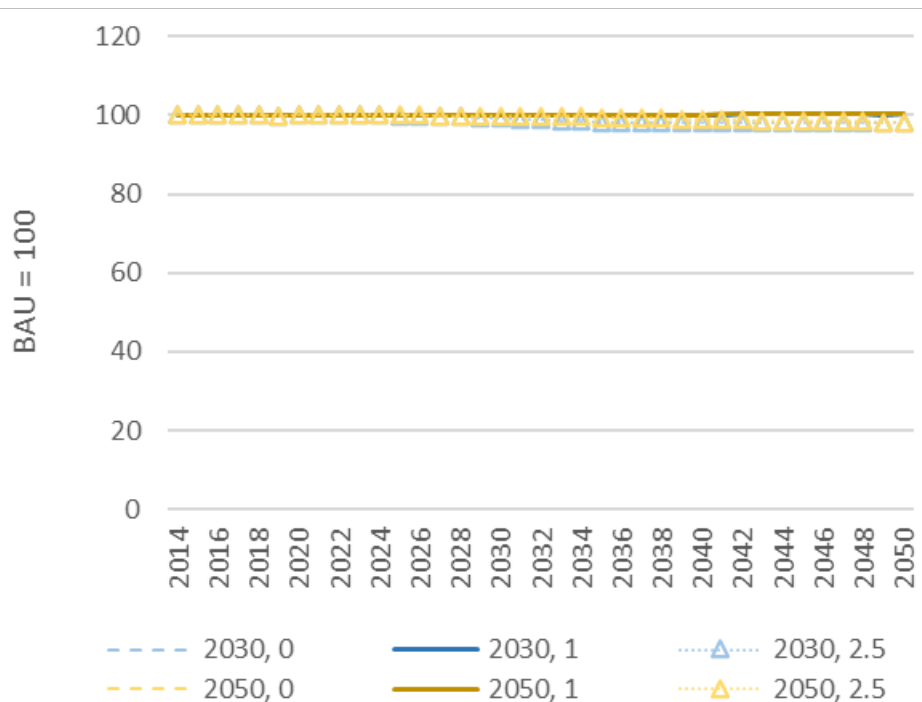


Other livestock than cattle more affected due to profitability in milk production (quota rents)

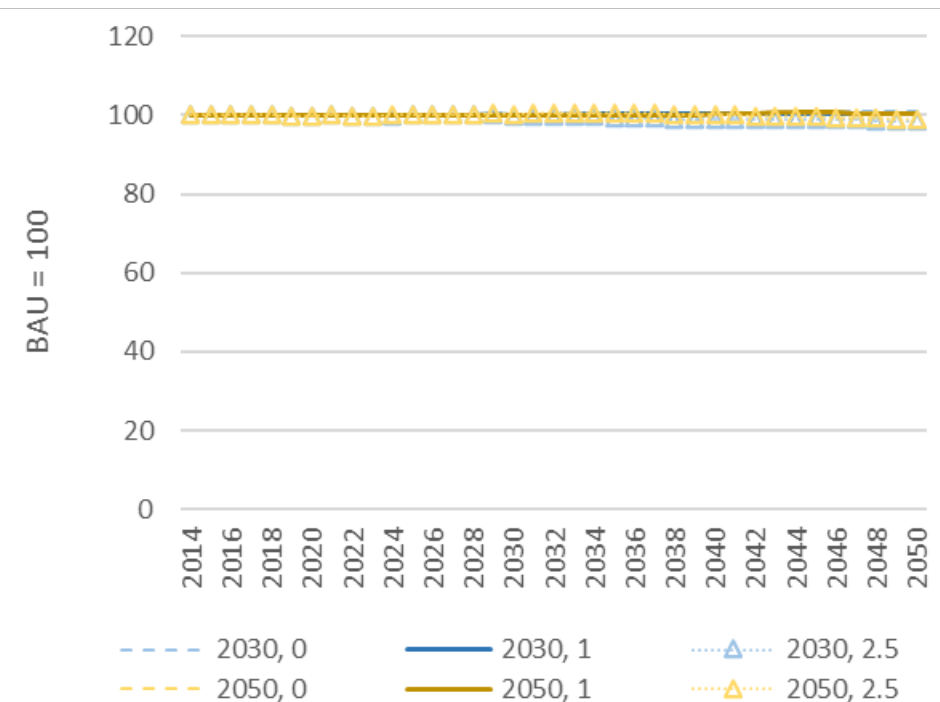


Agricultural input (land, labour, farms) largely unaffected

Total land use (farmed land)

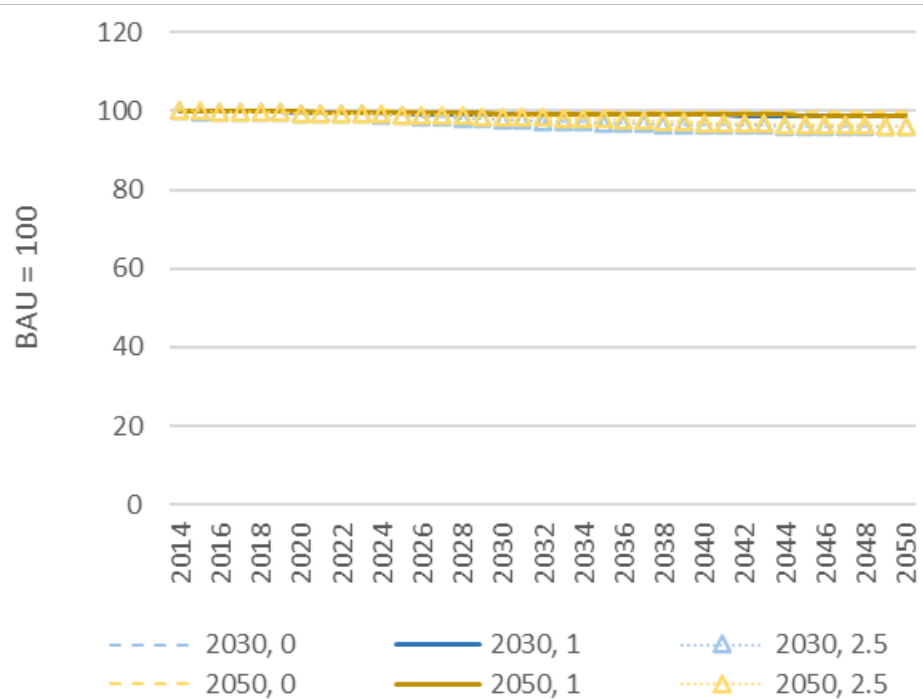


Active farms

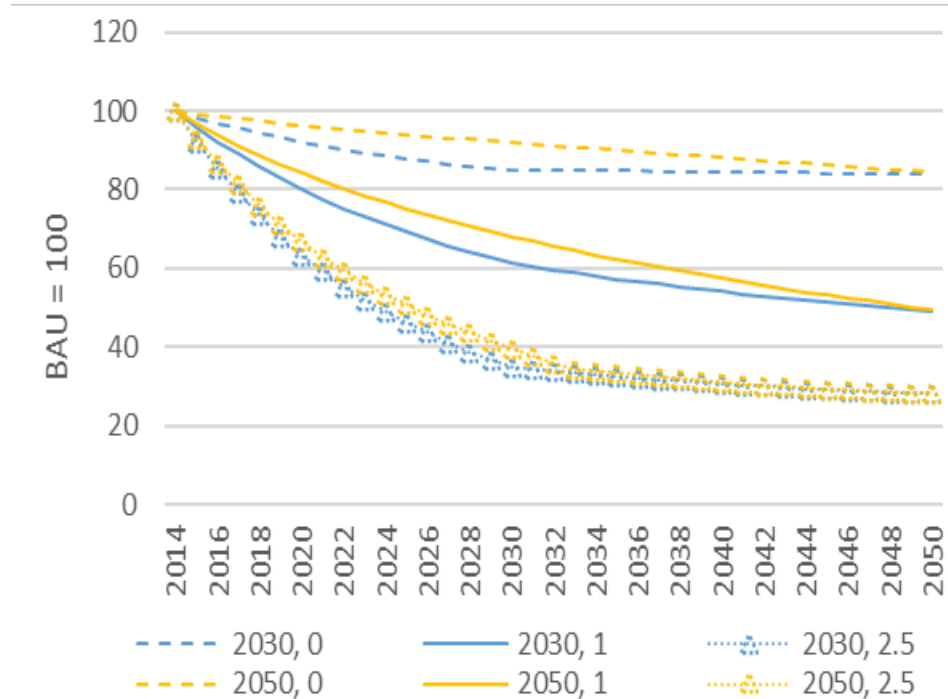


GHG emission reductions of Norwegian food demand take place in foreign countries

GHG from domestic food production



GHG from food import



Discussion and conclusion

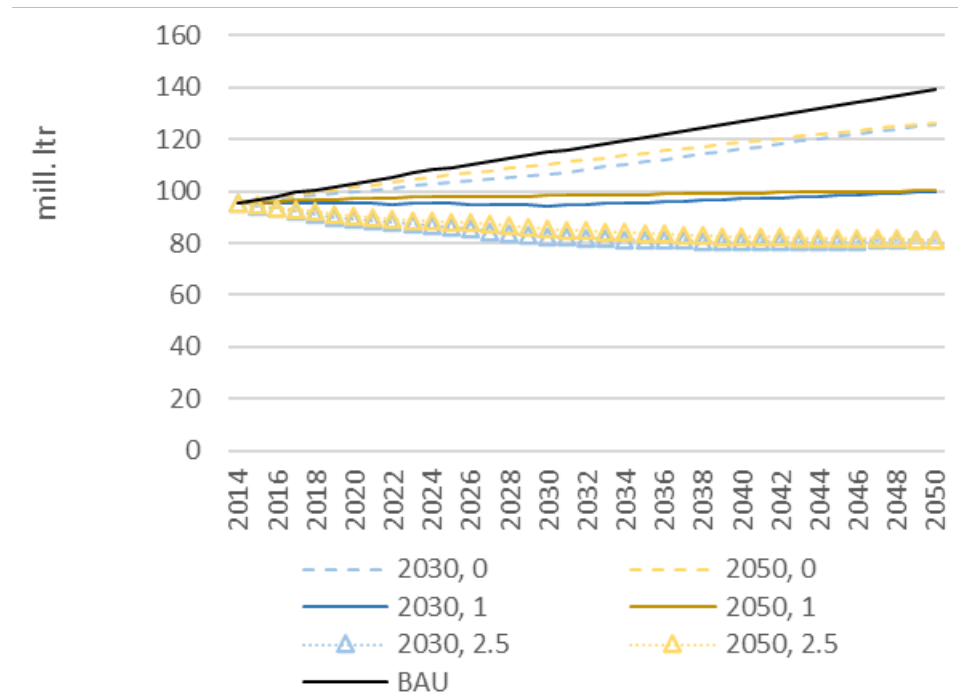
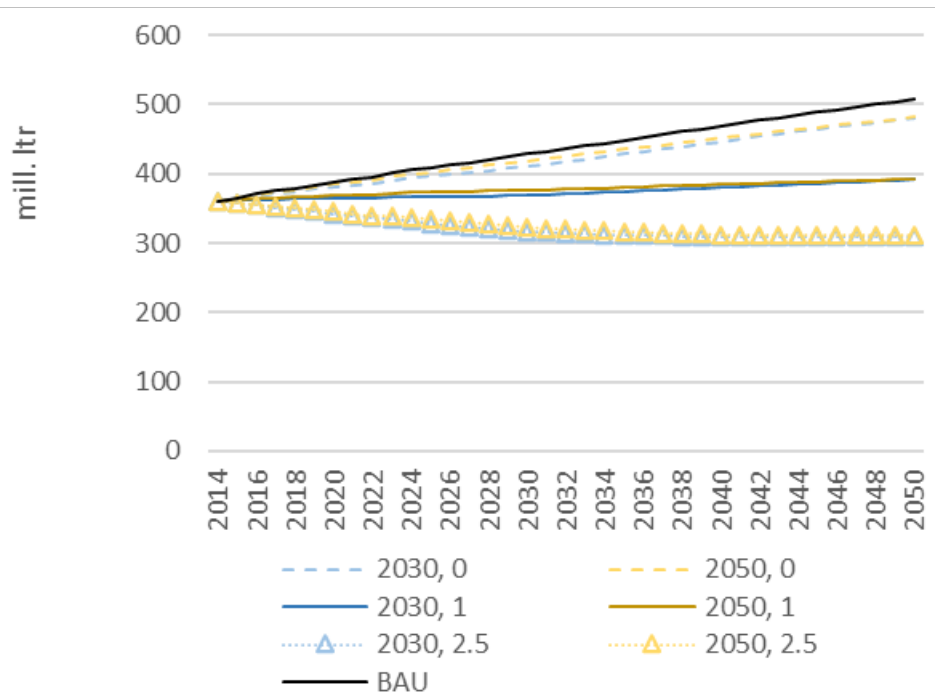
- Assumptions about preference shifts more important than assumptions about price alignment
- If/when cultivated food arrives on the market, its impact on agriculture will depend on how additional food consumption between now and then is met
 - There is probably room for both conventional and cultured food
- Caution: Uncertainty in most parameter values
 - Models [like large scale maps] may prove useful for orientation, but not for navigation

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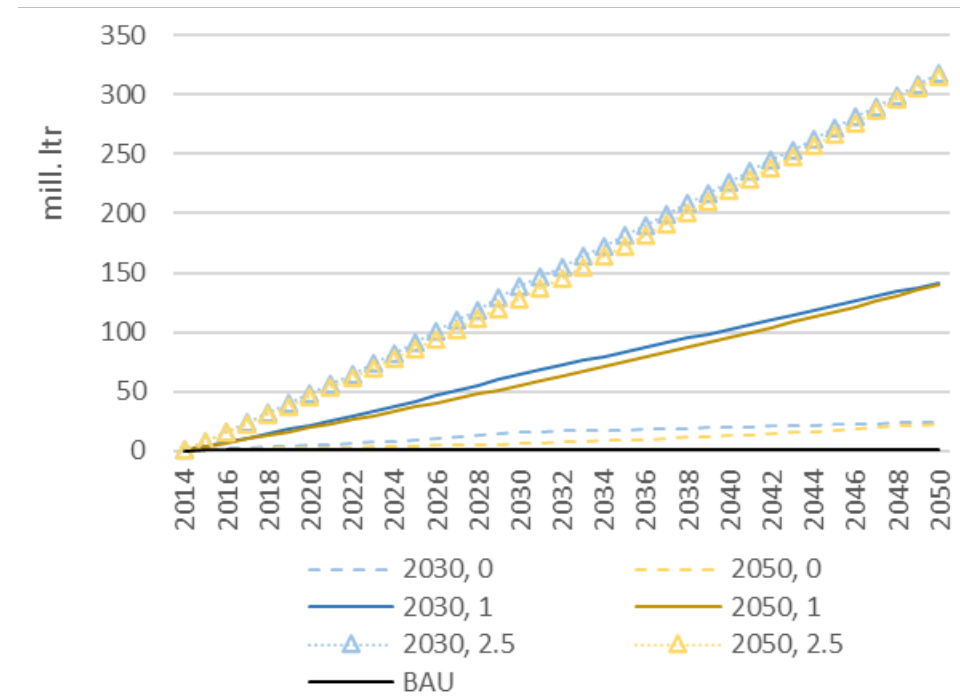
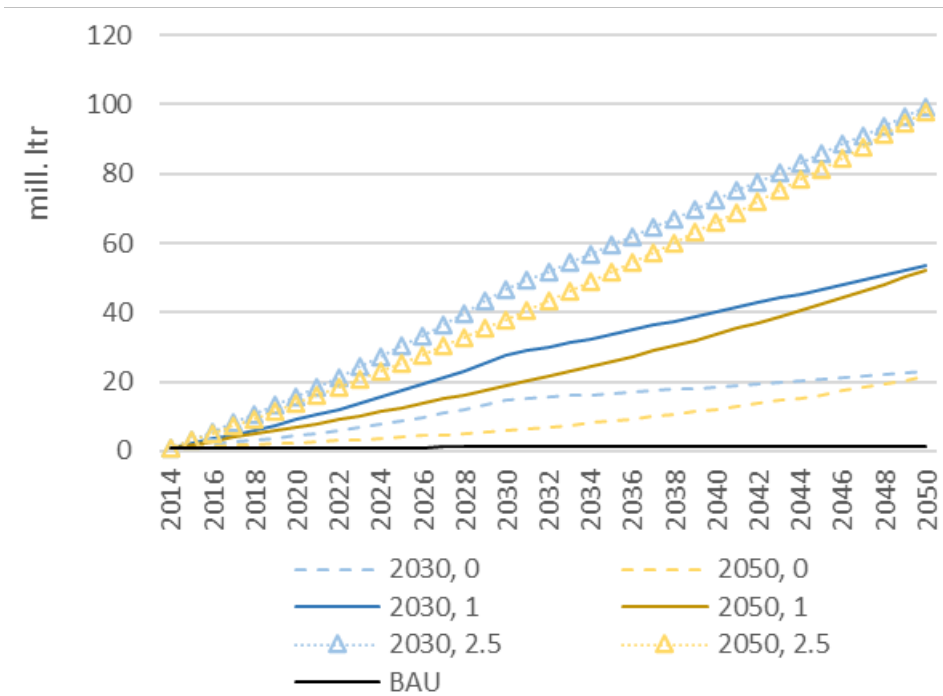
Cultured protein transition determined by preference shift rather than price development?



Final demand of the substitutes of the cultured protein-based dairy product (left panel) and of the cultured protein-based meat product (right panel) by year of price alignment and preference shift (mill. kg, 2014-2050)



Speed of technological development not crucial in the long run



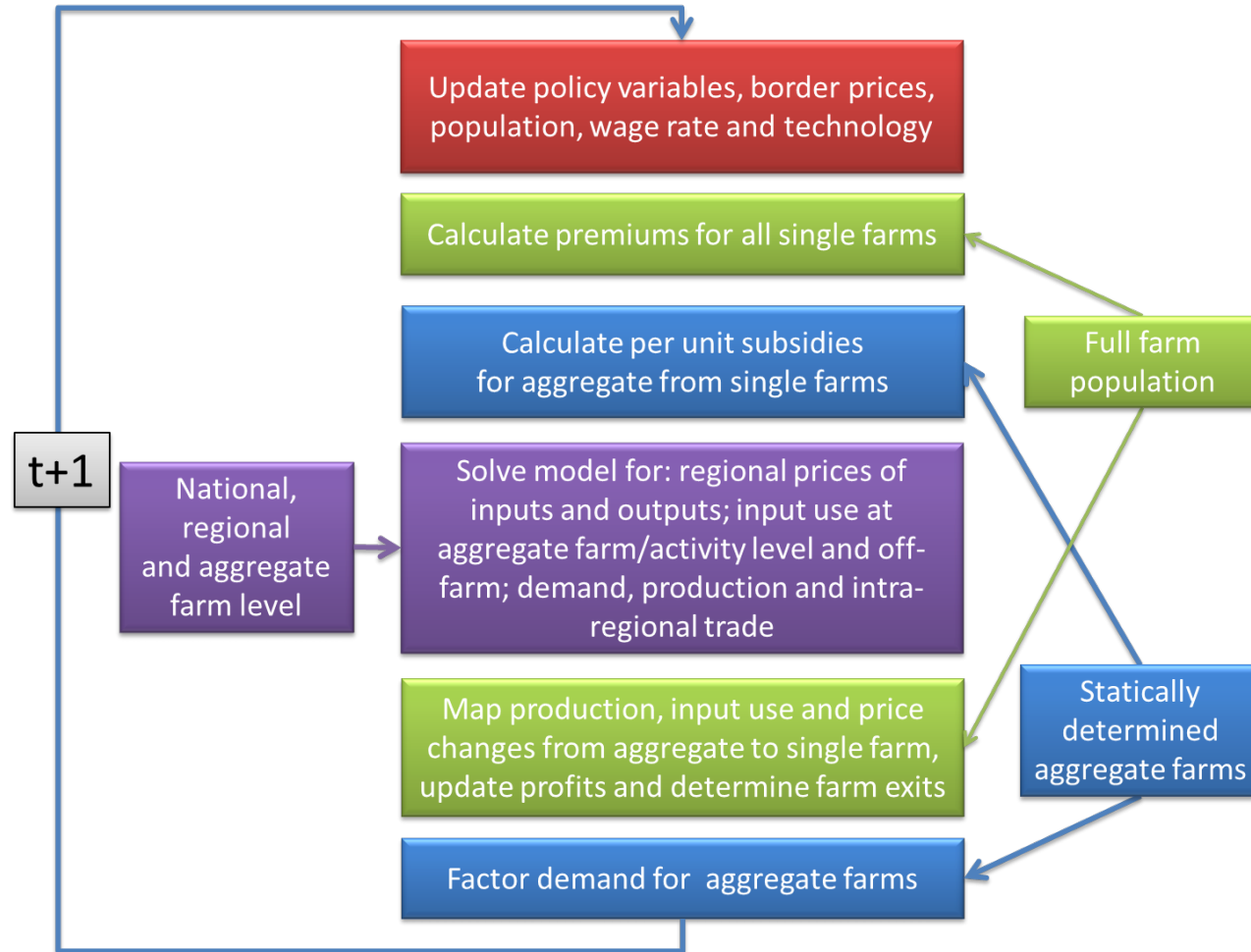
Final demand for cultured protein-based dairy product (left panel) and cultured protein-based meat product (right panel) by year of price alignment and preference shift (mill. kg, 2014-2050)



Agrispace: Model overview

- Aim: To analyse the path of adjustment caused by an exogenous shock (e.g., policy reform) for agriculture in Norway
- Dynamic-recursive: Solves for annual equilibrium starting from base year 2014
- Spatial: single farms – farm clusters – regions – country – global
- Covers all farms applying for subsidies
- Endogenous structural change in agriculture based on farm income and stochastic income threshold

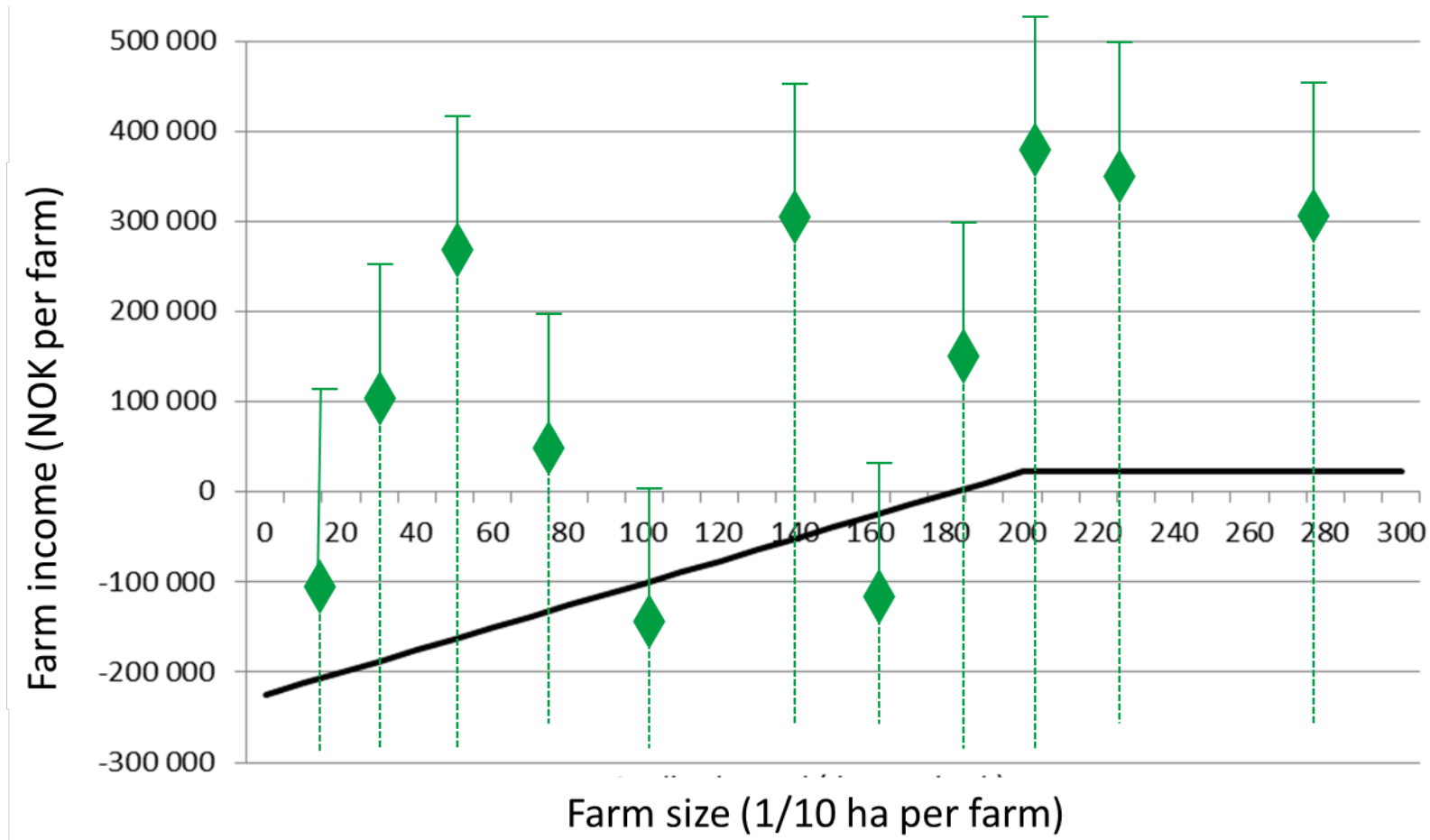
The core



Supply

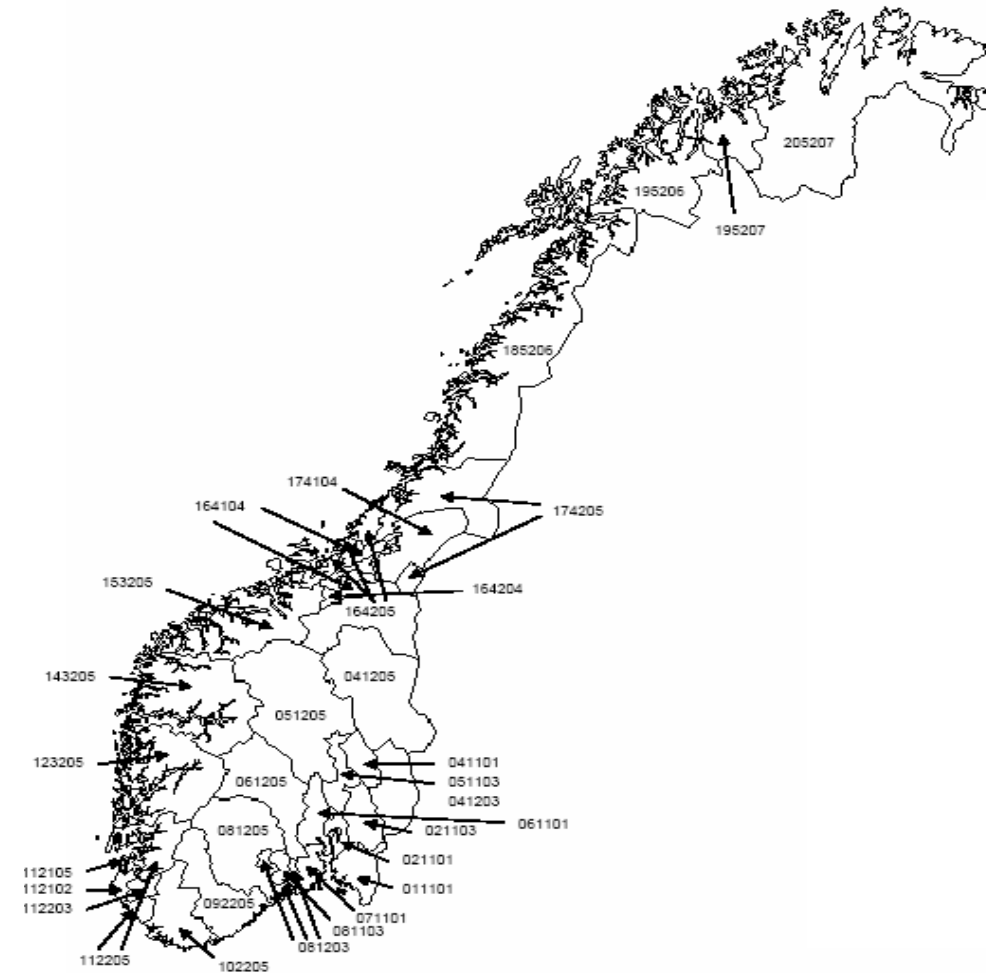
- Normalized quadratic profit function: covers outputs, 4 types of feed, 3 primary factors and other inputs (intermediates)
- Parameterization based on sensitivity analysis, regularity conditions (homogeneity, symmetry, curvature)
- Partial adjustment approach
- Simple price expectations (50% last and 50% current year)
- Production quotas based on MCP (endogenous quota rents)

Determination of farm exit: Area-dependent and stochastic income threshold



Market module

- 33 regions (NUTS III), 26 products plus 4 feed aggregates, 3 primary factors and one intermediate aggregate
- Mixed Complementarity Problem, PATH
- Homogeneous products, but explicit transport flows cost => Spatial Arbitrage \leq price differences cannot exceed transport costs + tariffs
- Flexible functional forms for final demand, and supply (salvage to extent possible from CAPRI) => welfare analysis
- Parameterisation of prototype based on CAPRI



Final demand

- Final demand: Flexible Generalized Leontief Expenditure System, parameterized according to regularity conditions (homogeneity, symmetry, curvature, additivity)
- Consumer prices differ from market prices by additive margin and CSEs (dairy), captures costs of processing and marketing
- 18 regions (NUTS III), 26 products plus 4 feed aggregates, 3 primary factors and one intermediate aggregate
- Mixed Complementarity Problem, PATH
- Homogeneous products, but explicit transport flows cost => Spatial Arbitrage <= price differences cannot exceed transport costs + tariffs
- Flexible functional forms for final demand, and supply (salvage to extent possible from CAPRI) => welfare analysis
- Parameterisation of prototype based on CAPRI

Policy instruments and welfare analysis

- Policy instruments: tariffs, production quotas, coupled payments to outputs or primary factors
- Welfare analysis:
 - Profits from agriculture and dairy
 - Costs of supplying primary factors to agriculture
 - Money metric for consumer
 - Tariff revenues, budget support (costs for coupled payments)