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Analysing Farm-specific Payments for Norway using the Agrispace Model

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Abstract

Norway maintains a complex system of activity or type specific coupled payments which account for a large share of farm income. Most of the payment rates are negatively related to farm size and are higher in remote areas compared to central regions. We present and use a newly developed recursive-dynamic multi-commodity model (Agrispace) with CES production functions depicting regional farm clusters derived from the full farm population. Using this model, we simulate impacts of current and alternative subsidy policies on production, prices, input use, income and farm structural change. Mapping cluster results to each farm along with behavioural rules allows estimation of individual profits and farm exits. Our results indicate that, in the short run, the current policy regime seems to support the policy objective of maintaining a variety of farms in all parts of Norway. In the long run, farm structural change is less affected by a policy reform that leaves total support levels unchanged.

Keywords: *Norway*; *policy reform*; *programming model*; *structural change*.

JEL classifications: *Q18, Q12, C61.*

1. Introduction

The design of agricultural policies has become more farm-specific in most OECD countries over the past decades in the sense that market support has been replaced by payments determined by individual farm characteristics such as land areas, endowments, production systems and intensity. Recent examples from the European Union' Common Agricultural Policy (CAP) include the Small Farmers Scheme that simplifies the Single Farm Payment requirements for small farms, 'greening' and 'capping' agri-environmental payments under Pillar II. A certain level of 'cross-compliance' has been part of agri-environmental payments since the late 1980s (Burton and Schwarz, 2013). In Norway, most subsidies are based on coupled payments with rates which are negatively related to farm size (i.e. crop levels, animal herds or the farm as such) (OECD,

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2016a). In addition, payment rates are regionally differentiated with higher rates in disadvantaged regions. These coupled payments represent a large share of agricultural income, considerably exceeding market based gross margins in most farming activities despite very high border protection which drives domestic market prices well above world market levels (OECD, 2016a). Furthermore, distances are large so that transport costs can be important for input and output prices faced by Norwegian farmers, and are partly subject to policy intervention.

Analysis of the current Norwegian agricultural policy requires detail for types of production, farm sizes and regional resolution. However, no appropriate state-of-the-art quantitative tool to inform domestic agricultural policy decision-making in Norway with these features is currently available. Jordmod (Bullock *et al.*, 2016) was specifically developed as an agricultural sector model for Norway, but has methodological weaknesses. It is a linear programming (LP)-based system which first optimises typical farms and next, taking these optimal programmes as fixed, determines 'optimal' weights in the farm populations to clear domestic markets. It struggles with the typical over-specialisation of LPs in its farm type supply module and unrealistic assumptions underlying the market module. As a complement to Jordmod, specifically for market- and trade-based analysis, a Norwegian module for CAPRI (Britz and Witze, 2014) has been developed which also includes regional average payments for many of the Norwegian subsidy schemes, but does not provide data for the farm type extension of CAPRI (Gocht and Britz, 2011). Simulating Norwegian domestic policy reforms with CAPRI is hence confined to varying available average regional payment rates, which is insufficiently detailed for realistic policy analysis.

To fill this gap, we present a newly developed tool, Agrispace, to inform agricultural policy decision-making in Norway. The basic concept is to utilise information from the full population of Norwegian farms applying for direct payments in a model with explicit demand and production functions. Agrispace is inspired by the complexity of Norwegian agricultural policies, but in principle is applicable to any other regional, national or European level where similar data are available.

The remainder of the paper is organised as follows. Section 2 gives a short overview of Norwegian agricultural policies. After a brief presentation of the model's major building blocks in section 3, scenarios aimed at illustrating and assessing the model's features are introduced in section 4. The scenarios are built around a payment implementation uniform with respect to farm size and regional location. Section 5 reports on changes in prices, supply, farm income and structural change. We conclude and discuss strengths and weaknesses of the model in the final section.

2. Norwegian Agricultural Policies

Using budgetary spending and market distortion as indicators, Norwegian society seems to put a high value on maintaining agricultural production and preventing higher rates of structural change in the Norwegian farm population as well as preserving a degree of self-sufficiency in food markets. In 2015, overall support to agriculture was 26.3 billion NOK (OECD, 2016b), equivalent to around €2.94 billion. Border protection and budget support amounted to 12.1 billion NOK (€1.35 billion) and 14.2 billion NOK (€1.59 billion), respectively. Market sales valued at world market prices represented 13.9 billion NOK (€1.55 billion). In effect, around 60% of the sector's gross production value was related to government intervention and financed by either tax-payers or consumers (OECD, 2016b).

In the latest White paper on Norwegian agricultural policy (Ministry of Agriculture and Food, 2016), the four stated main goals are food security, agriculture all over the country, increased value creation, and a sustainable agriculture with lower greenhouse gas emissions. In its debate on the White paper, the Parliament specified that 'agriculture all over the country' implies a diverse agriculture with a varied farm structure (Norwegian Parliament, 2016). It argues that natural conditions in many rural areas limit farm size such that there is a need to support the existence of small farms as a precondition to maintain agriculture all over the country.

Such support comes in many different programmes. Subsidies are mainly paid based on output, animals and farmed land. In addition, there are significant investment programmes and tax allowances for income from agriculture. Payment rates are commonly based on actual rather than historic farm production and thus are coupled to production decisions. The OECD Producer Support Estimate (PSE)-database distinguished 97 different payment schemes for Norway in 2015 (Table 1). There were 21 payment schemes with farm size degressive payments rates only, seven schemes with regional differentiation only and 6 programmes where rates differed both with regard to farm size and region. Although the support granted in each individual scheme might be small, the total share of budget support associated with farm size and/or regional differentiated payment rates is almost 70%. In addition, support at the farm level was capped based on farm size in nine programmes, which in sum account for almost 50% of overall budget support to agriculture.

Norwegian agricultural policies also comprise supply control at market level. Most important for the purpose of the model are farm-specific milk quotas which are tradable only at the county level. As Norway consists of 18 counties, the quota regime is an important tool to prevent concentration of dairy farming in a few more favourable regions, which has impacts for the majority of the farms given the importance of milk production in a country with limited arable land.

That brief overview shows that individual farm characteristics have to be taken into account in any *ex-ante* economic analysis of Norwegian agriculture policy reforms. Whereas access to individual farm data is often a key limiting factor in policy evaluation in many countries, the Norwegian Freedom of Information Act ensures that data regarding state aid paid to legal entities or private persons including agricultural subsidies have to be made public on request. Thus, annual data at individual farm level on the number of hectares of eligible crops and the number of eligible animals are

Table 1

Characteristics of direct payments in Norway

	Number	Amount (million NOK)	Share (%)
All payments	97	14,177	100
Payments with farm-size degressivity (FSD) only	21	4,134	29.2
Payments with regional differentiation (RD) only	7	4,005	28.3
Payments with both FSD and RD	6	1,419	10.0
Payments with cap for total payment amount	9	7,005	49.8

Source: Own calculation based on OECD (2016a,b).

stored in a Direct Payment Database and can be requested from the authorities. The database provides data in electronic form back to 1999. Given the importance of budget support for farm income and that payments apply to almost any crops grown and almost any animals kept on farms (including mink, bees, deer, rabbit, alpaca, donkeys and lama), only a few farms are not covered by the Direct Payment Database. However, data on production costs and revenues as well as farm-household characteristics are not included in this database.

It is not clear that the existing Norwegian policy mix delivers the desired outcomes in a cost efficient way. For any larger legislative project,the European Union (EU) requires a formal impact assessment and explicitly recommends for policy arenas such as the Common Agricultural Policy (CAP) the application of economic modelling in its impact assessment guideline (EU, 2009). In contrast, agricultural policy decisions in Norway are mostly not informed by quantitative tools and impact assessment. That might partly reflect that farmers' association and the government led by the agricultural minister decide on an annual basis on changes in subsidies, without too much interest by the general public about budgetary consequences and without major reforms in policy instruments such as those undertaken in the CAP over the last decades. The observed lack of quantitative analysis could also reflect the lack of existing tools and models which could inform the policy debates. Current tools lack features to match salient outcomes with the information needs of stakeholders and a state-of-the-art methodology (see Podhora *et al.*, 2013).

3. Overview on the Agrispace Model

The agricultural sector in Norway is small in economic terms (about 1.5% of gross domestic product (GDP) including considerable subsidies) and characterised by small shares for any agricultural and food product in world markets. In contrast to most other European countries, research can gain access to data on the full farm population. Against that background, the Agrispace model is built around the following building blocks: (1) small country assumption, i.e. fixed world market prices, in a partial equilibrium (PE) setting, (2) consideration of price differentiation inside Norway based on a Spatial Equilibrium approach, and (3) a recursive-dynamic link between results for each farm in Norway and results for aggregate farm types at regional level.

More specifically, Agrispace is a recursive-dynamic multi-commodity model (MCM) with behavioural equations to determine demand and explicit production functions for agricultural sectors, the feed compound and the dairy industry, similar to Computable General Equilibrium (CGE) models or the Policy Evaluation Model (PEM) of the OECD (Martini, 2011). Based on the spatial equilibrium (SPE) approach, we consider commodities as homogenous, such that price differences in space depend on transport margins and policy instruments such as import tariffs, and not on spatially differentiated quality differences as in the Armington approach (Armington, 1969). SPE reflects spatial arbitrage, i.e. price differences between two regions cannot exceed the bi-lateral per unit transport and transaction costs. A regular demand system is necessary to calculate welfare results from any price changes resulting from changes in agricultural policy. We assume that markets are competitive, and that producers minimise costs and consumer utility, standard assumptions in PE and CGE models. These assumptions are reflected firstly in the choice of functional form and parameterisation for the demand side: we use (semi-)flexible function forms and ensure global adherence to regularity conditions. Secondly, for the supply side, we use

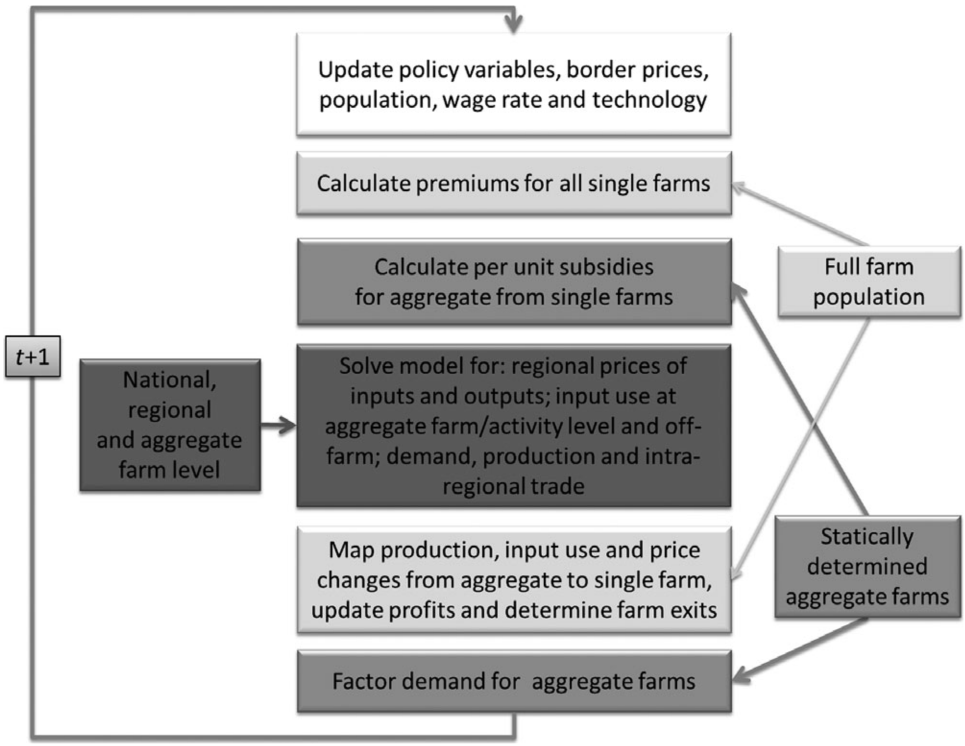

Figure 1. Flowchart of the Agrispace model

first order conditions (FOC) derived from constant elasticity of substitution (CES) production functions under constant-returns-to-scale in combination with constant elasticity of transformation (CET) functions to describe factor supply, the usual approach in CGEs. Jointly, the functional forms and parameterisation allow for consistent welfare analysis with the model. Given this structure, the model's equations depict four types of (in)equalities: (1) FOCs derived from cost minimising under explicit production functions which define input demand at given prices and per unit production cost, (2) the demand equations which define demand quantities at the endogenous prices, (3) market clearing conditions which define regional prices, and (4) spatial arbitrage which simultaneously determines inter-regional trade flows and differences in regional prices. As mentioned above, we treat international prices as fixed. An overview of the data flow in the model for each annual step is shown in Figure 1. For detailed technical and methodological documentation of the model, refer to the online model documentation (Britz, 2017).

3.1. *Supply side*

The supply side of the models breaks down each of the 32 regions into 4–16 clusters of farms which are modelled by aggregate production and factor supply functions. Each region consists of municipalities that belong to the same county, the same zone for acreage and landscape payments, and the same agricultural region. The latter category divides Norway into eight regions with similar natural conditions for agriculture

(NIBIO, 2016). The farm clusters in each region are derived by statistical analysis from 42,180 individual farms applying for direct payments in the calendar year 2014 and depicting almost the entire Norwegian farm population. Some farms do not apply for subsidies, and some farms have been dropped because of very small or less relevant production activities (e.g. horses, bees). That implies that each cluster represents an average of 140 farms. The cluster analysis was undertaken using the *kmean*-approach in Stata which is an iterative procedure that partitions the data into k groups or clusters (StataCorp, 2011). As k is exogenously given, the *kmean*-approach has been run for $k = 1, \ldots, 20$. In order to determine the optimal number of k, two tests have been applied: the within sum of squares (WSS) (Makles, 2012) and the Calinski-Harabasz pseudoF (Calinski and Harabasz, 1974). The optimal number of k has been finally determined by visual inspection of the graphs generated from the WSS and the pseudo for a given k. A kink in the WSS-curve indicates the optimal k as do large values of the pseudoF.

Output generation for the 19 agricultural products covered by the model (six types of cereals, rapeseed, pulses, potatoes; tomatoes, other vegetables; apples, pears and peaches as an aggregate, other fruits, fodder production, beef, pork and poultry meat, eggs and raw milk) and input use of each cluster is described by product-specific nested CES production functions with constant returns to scale. Capital, land – differentiated by arable, permanent and grassland – labour, general intermediate inputs, fodder and concentrates are the six input categories identified. The top nest of the production function includes the intermediate composite, a composite of labour and capital, all feed (for animals) and for crops, land. Feed for ruminants is differentiated in a further nest comprising fodder – assumed to be not traded across farm clusters or regions – and a feed compound composite.

The production activities compete at cluster farm level for the two quasi-fixed factors: capital and labour; and the three land categories. That competition is described by CET-functions; we hence assume that input qualities used in the different production branches in one (aggregate farm) differ such that factor returns need not be identical. Total supply of capital and labour to the cluster of farms is driven by a linear function depending on the relation of average returns on farm and off-farm prices which can hence be understood as a farm-household model with preferences for on/off farm employment and capital use, and diminishing returns to capital and labour use on and off-farm.

The three land categories feature regional markets, where the total land stock reacts with land supply elasticities to changes in average regional returns. The average regional returns represent a CET nest which distributes land to the different farm group (clusters) according to average returns to each land category in the cluster. That in turn implies that land markets are not perfect: returns between the aggregate cluster farms are not identical.

Feed demand for each production branch is depicted by a CES function which differentiates between different types of compounds and single feed stuffs (soy cake, cereals based, dairy based and other). A feed compound industry mixes these compounds together based on cost minimisation under a CES technology comprising labour, capital and the individual products mixed together. The dairy industry features a CES technology combining raw milk, labour and capital to one output which is CET transformed to the individual dairy outputs (butter, skimmed milk powder, cheese, fresh milk products, cream, concentrated milk, whole milk powder). There is no other explicit food processing industry, rather, fixed processing margins differentiate producer price net of per-unit subsidies from final consumer prices which implies constant-returns-to-scale such that no change in welfare in food processing needs to be reflected in the model.

The model hence simultaneously simulates allocation decisions at the level of farm groups as in a classical aggregate programming model, however using non-linear production functions, and aspects of structural change, depicted by simulating changes in labour and financial assets (=capital) on and off farm and competition in land markets between farm groups. At the same time it generates, as a typical MCM, changes in production, demand, trade and prices at the national level, and from the SPE approach, also at regional level inside Norway.

To explain the interactions on the supply side depicted in the model, consider an example relevant for the policy analysis in the results section. Norwegian subsidies in milk production are degressive, i.e. small farms receive higher per unit subsidies. Assume that this differentiation by farm size is removed. The returns to factors to milk production in small farms will drop as a result. This has three consequences. First, at the farm level, activities other than milk production competing for labour, land and capital will be expanded in small dairy farms. Second, at the household level, despite that re-allocation, average returns to factors in small dairy farms will drop and the household will (re)invest less in the farm and also move labour from the farm into the household, for off-farm work or other purposes. Third, in the land market, the small dairy farms will lose competiveness and part of their land will be shifted to other farms and non-agricultural use. The opposite effects will be observed for larger dairy farms where per unit subsidies to milk production will increase when subsidies no longer depend on farm size. Next, we discuss how such simulated changes interact with the micro level.

3.2. *Estimating changes at single farm level*

As mentioned above, the MCM model operates on the supply side at the level of farm groups inside each of the 32 regions, our farm clusters, which were defined by statistical cluster analysis taking acreages and herd size of the different activities into account as discussed above.

In order to re-calculate the premiums and estimate farm exits, we map the simulated changes in output quantities and land use in each simulated year in relative terms into each single farm reported by the agricultural census. As the netput quantities for the each cluster are consistent to the sum over the single farms at the benchmark, applying relative changes to each farm maintains the consistency between micro level and the partial equilibrium model results during simulation as well. That rather simplistic approach based on relative changes is often applied in studies combining macro- and micro-simulation (*cf*. Bourguignon *et al*., 2008 for use in macro-micro simulations for general or Deppermann *et al*., 2016 for an application to single farms). Resulting changes in labour and capital costs at micro level reflect simulated changes in production output level and cost shares relative to the originally estimated labour and capital costs of each single farm. From there, it is possible to estimate the individual farm profits, given that the detailed premiums are calculated for each farm as well. The approach seems especially suitable in our context given the relatively high level of differentiation in our farm group approach where each cluster represents on average only 140 farms, and the attributes in the cluster analysis are equal or strongly related to the variables where uniform relative changes are applied.

Deriving per unit subsidy at the aggregate level from micro results is important as activity-specific subsidies are differentiated by enterprise size such that, for example, the first cows receive higher premiums. Furthermore, for certain payment schemes, total payments to a farm cannot exceed given thresholds. We differentiate the twelve most important different payments schemes in terms of budget support in detail plus an aggregate residual category which ensures consistency with the PSE data of the OECD.

To determine farm exits, we employ a simple algorithm based on a farm size-specific profit cut-off level and a stochastic component. The sample comprises a larger number of relatively small farms with low profits, often involved in sheep farming and keeping horses. Applying a profit cut-off based on a comparison with factor returns out-of-agriculture will not reflect intrinsic motives which might well explain the decision to continue to operate these small-scale farms. Statistics show that a significant number of farmers do not leave the sector despite negative income. On average, about 12,000 farmers (or 27% of all farmers) had negative taxable income from agriculture for each year between 2004 and 2015, while only 1,700 farmers exited the sector (Statistics Norway, 2017a). Furthermore, more than half of the farms with less than 0.5 ha had negative taxable income from agriculture in 2015, while that share was only 8% for farms with more than 50 ha (Statistics Norway, 2017b). Hence, we assume a lower cut-off level for smaller farms. The farm-specific minimum profit increases linearly from a profit of €–25,000 for farms with less than 0.1 ha to a profit of €2,500 for farms with 20 ha. The cut-off level remains constant for all farms above that size. The farm-specific minimum profit is hence size specific. Next, we allow for different shares of capital costs being accounted for, assuming that the remaining difference between revenues plus premiums minus variable costs will remunerate labour and land. Furthermore, we randomly disturb the profit cut-off for each farm based on a normal distribution to reflect stochastic impacts on exit decisions such as death, illness and accidents, breakdown of farm machinery, but also events such as marriage or an unexpected labour opportunity off-farm. The standard deviation of the stochastic elements depends on the yearly changes of profits corrected for the change in the overall wage rate: a drop (or increase) in each individual profit increases (or decreases) the standard deviation and thus increases (or decreases) the chance of a farm exit. To summarise, exit conditions reflect the size of an individual farm's profit and its yearly change, with a stochastic element. The different parameters used in the farm exit module have been calibrated to arrive under the benchmark simulation over a decade to the about the same rate of structural change as observed *ex post*.

Next, we need to map the changes resulting from individual farm exits back to the cluster level. In order to do so, we first calculate the relative change in the output quantities of the cluster by subtracting from the current output level the output of the exiting farms, in relation to current cluster output. Given that the clusters operate under constant-return-to-scale, we can use that relative correction factor as well to correct input use for the individual products. That also implies that calibrated costs shares are not affected. In order to get a feedback from these changes on the simulation behaviour, we recalibrate the CET-factor supply nests for the next year simulation with the MCM part such that the reduced input demand quantities would be demanded at the old input prices which reflect the behaviour of the non-exiting farms under the last simulated market and policy conditions. That in turn implies that the feedback from structural change on the solution in the next year is driven by the factor supply functions which are unchanged. With reduced factor demand due to farm exits, factor prices in the next year's solution of the MCM part such as land prices will drop, and the remaining farm cluster will face lower prices which will lead to adjustments in factor use in the remaining farms and consequently to changes in outputs and output prices. Note that feedback via output market is limited as border prices are exogenous. Regional prices compared to the benchmark will hence only change if either border policy instruments change or regions switch from a net-supplier to a net-demander reflecting spatial arbitrage.

3.3. Technical implementation

Similar to most other tools in that field (e.g. Britz and Kallrath, 2012), we use GAMS (General Algebraic Modelling System, Bisschop and Meeraus, 1982) to encode the model and all necessary data and parameter transformation. Coding conventions, for example with regard to a modular structure and use of mnemonics, follow guidelines developed for CAPRI (Britz, 2010). For the Bayesian based parameter calibrations, we use CONOPT (Drud, 1994; version 2014), the market model is solved in PATH (Ferris and Munson, 2000) as an MCP. A Graphical User Interface allows steering the model and results exploitation, which is implemented in GGIG (GAMS Graphical Interface Generator, Britz, 2014).

4. Scenarios

A series of model runs was conducted to better understand model behaviour and model responsiveness to certain exogenous policy shocks. As the main motivation for developing the model was to study the effects of policy reform on the regional distribution of agricultural activities and farm structural change, the scenarios were built around combinations of the abolition of the payments' farm-size degressivity and regional differentiation. As the model is recursive-dynamic, we also included two scenarios to study the effects of varying the timing of the policy changes. Table 2 identifies the seven scenarios for which model runs have been performed.

The abolition of farm-size degressivity and regional differentiation was implemented in the same way in all scenarios in order to allow comparability across scenarios. Removing farm-size degressivity of subsidies was based on calculating uniform payment rates for every activity and payment type such that relative differences across

Table 2

Scenario definition

	Abolition of . . . in year . . .	
Scenario name	Farm-size degressivity	Regional differentiation
(1) *Baseline*		
(2) *NoReg*		2015
(3) *NoSize*	2015	
(4) *NoAll*	2015	2015
(5) *NoSizeNoReg*	2015	2017
(6) *NoRegNoSize*	2017	2015

activities and payment types were maintained. Under constant regional differentiation of payment rates (i.e. *NoSize*), payment rates are uniform at regional level. In all other cases (i.e. *NoAll*, *NoSizeNoReg*, *NoRegNoSize*), uniform payment rates were calculated at the national level.

When the regional differentiation of payment rates was removed, a slightly different approach was used. Payment rates were still calculated per payment type and activity. First, the payment sum per region, payment type and activity was calculated based on activity levels in the base year and given national uniform payment rates. If farm-size degressivity was maintained (i.e. *NoReg*), the step-wise payment rates in the base year were adjusted with the percentage change of the payment sum calculated in the first step and the payment sum in the base year. If, in addition, farm-size degressivity was abolished (i.e. *NoAll*, *NoSizeNoReg*, *NoRegNoSize*), the calculation of payment rates followed the method described above.

The policy changes were implemented in one step (2015) in three scenarios (i.e. *NoSize*, *NoReg*, *NoAll*) and in two steps (2015 and 2017) in the two other scenarios (i.e. *NoSizeNoReg*, *NoRegNoSize*). Policy reforms are integrated step-wise over a longer period to soften the adjustment process.

Trade policies were kept unchanged in all scenarios as the scenarios study domestic policy reform only. The final simulation year was set to 2024. The most important exogenous assumptions across all scenarios regard population growth (+1% per annum at national level, using regional projections where growth rates differ), income growth (+2% per annum), and world market prices (–2% per annum, reflecting also a strong NOK). Furthermore, wage rates are assumed to increase at 2% per annum and returns to capital at 1.5% per annum. Results are compared to a baseline scenario ('-line') in which payments and milk quotas are kept at their base year levels, but the exogenous assumptions above are implemented over 10 years.

5. Selected Results

Based on its product, regional and farm group detail, the model produces a large number of relevant results to inform policies which cannot be presented in full. As the focus of the paper is on regional distribution of agriculture and on farm-structural change, we present results on the regional distribution of farmed land, the regional distribution of raw milk production, the number of exiting farms, and the development of farm size measured in ha. To those specific results, we add overall information on welfare, income, production, prices and payments.

Table 3 shows key results for 2024 which is the model's last simulation year. Overall aggregated results remain about the same in all scenarios compared to the baseline. This is true for welfare, income, production and prices (the latter two not reported). Total welfare increases most compared to the baseline in the scenario with the immediate implementation of a full policy shock (*NoAll*), though even so the change is very small. In the two scenarios where policy reforms are delayed (i.e. implemented in two steps), total welfare is still higher compared to a partial policy shock (*NoSize*, *NoReg*), but slightly lower compared to the immediate implementation of the full policy shock. The latter result comes as payments and the income of input supply owners are slightly higher. However, the relative change in total welfare compared to the baseline is at most 0.026% in all scenarios. The limited differences clearly reflect that payments in our scenarios are redefined such that overall spend remains virtually constant, while the exogenous world market prices largely determine domestic Norwegian prices with unchanged border protection. Hence, the policy reforms basically redistribute income within the farming sector without changing much overall production, input use and activity levels.

All policy reforms clearly affect the rate of structural change at the time of implementation, but much less so in the longer run. Figure 2 shows the rate of farms exiting in a given year as a percentage of all farms in the previous year for the *ex-post* period 2000 to 2014 and the *ex-ante* period 2014–2024. Partly due to increasing support, structural change has been reduced prior to 2014 from more than 6% to less than 2% in terms of farm exits. Annual farm exit lies between 2–2.5% in the baseline. As expected, the magnitude of structural change is positively correlated with the scope

Table 3
Overall results (million €)

	Baseline	*NoReg*	*NoSize*	*NoAll*	*NoRegNoSize*	*NoSizeNoReg*
Consumer surplus	381,601	381,600	381,602	381,602	381,602	381,602
Farm income	2,954	2,949	2,946	2,940	2,942	2,940
Quota rents	162	166	162	164	166	167
Input supply owners' income	11,860	11,827	11,820	11,772	11,775	11,775
Payments	1,583	1,576	1,571	1,561	1,564	1,563
Total welfare	373,769	373,806	373,815	373,867	373,865	373,864

Source: Own calculations.

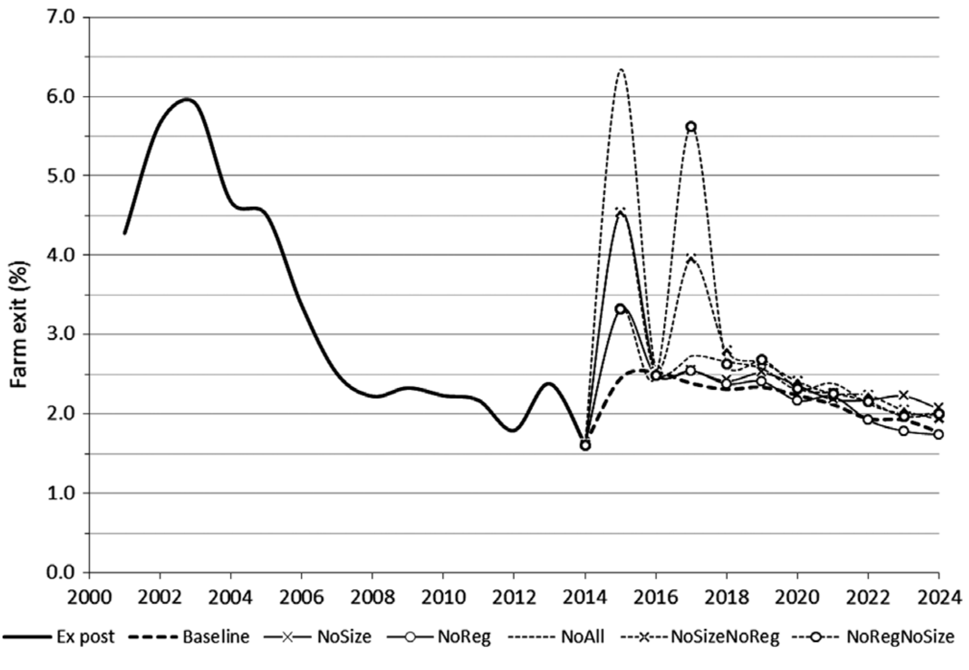

Figure 2. Farm exit defined as the share of farms exiting the sector of all farms in the previous year by scenario (*ex-post*: 2000–2014, simulations: 2014–2024)

and timing of a policy reform. Farms adjust in the current model setup quickly so that the rate of structural change falls back to baseline levels shortly after implementation. Farm exits peak at about 6% when both size-degressivity and regional differentiation are removed immediately (*NoAll*). The effects are considerably smaller when only size-degressivity or regional differentiation is removed. Farm structural change increases each time a policy reform is implemented. Two peaks appear in the scenarios where the reforms are delayed between 2015 and 2017. Figure 2 shows that the abolition of size-degressivity has more significant implications for farm exit than the removal of regional differentiation. It is interesting to note that the impact of abolition of regional differentiation is higher after the abolition of size-degressivity (*NoSizeNoReg*) than with size-degressivity in place (*NoReg*). The presence of size-degressivity seems hence to weaken the effect of removing regional differentiation, while this effect is not so pronounced in the opposite case. Table 4 shows that 8,306 farms leave the sector in this case between 2014 and 2024. Farm exit is lowest in the baseline with 6,803 farms. Extending the time span of policy implementation by two years reduces overall farm exit by about 100 farms. Size-degressivity seems to be more important to avoid farm exits (7,704 farm exits) than regional differentiation (7,086 farm exits).

A higher number of farms exiting the sector translates into a larger average farm size. However, this result is somewhat disturbed by the fact that total land use does not remain constant in all scenarios. Land use is highest (872,500 ha) when only regional differentiation is removed and lowest (850,062 ha) when both differential features are abolished at the same time, while land use in the base line is slightly above the lowest value (853,315 ha).

Size-degressivity seems to support the existence of small farms. The number of farms less than 6 ha and less than 10.45 ha is lower when size-degressivity is removed (*NoSize*) than in the baseline. The two size classes are chosen to cover the lowest 10% and 20% of farms in the baseline, respectively. Due to differences in total land use, however, the average farm size is somewhat lower when size-degressivity is removed. The number of farms exiting is highest when both characteristics are abolished. However, this does not lead to a higher average farm size compared to the baseline, because total land use is also reduced. The relationship between farm size variance and the removal of payment characteristics is ambiguous. If only farm-size degressivity or regional differentiation is removed, farm variance goes down, while variance increases if both characteristics are abolished. Policy reforms in which both characteristics are removed trigger larger adjustment processes which seemingly lead to a more diverse farm structure.

Regional effects on land use are shown in Figure 3 and exemplified for the scenarios '*NoSize*', '*NoReg* and '*NoAll'*. The darker the colour, the larger the reduction in land use compared with the baseline for the year 2024. Regions with light grey or white colour experience an increase in land use. The Northernmost regions observe a fall in land use by 4% when the regional differentiation in the support system is removed. This is true also for regions in Western Norway and Southern Norway when size-degressivity is abolished in addition to regional differentiation. As will be explained below, farms in these regions are in general smaller compared to farms in Eastern Norway, South-West Norway and Central Norway. Therefore, the abolition of size-degressivity also has regionally differentiated impacts. It appears that the regional differentiation of the payment system is more important to achieve the policy objective of maintaining agriculture across the country than size-degressivity.

Table 4

Farm size characteristics by scenario and simulation year

Scenario and simulation year	All farms		Farms < 6 ha		Farms < 10.45 ha		No. of farm exits
	Mean	Variance	Share (%)	No. of farms	Share (%)	No. of farms	
Baseline (2014)	28.4	764	10.56	3,601	23.04	7,861	
Baseline (2024)	33.0	1,023	10.01	2,733	20.01	5,464	6,803
NoSize (2024)	32.6	1,010	10.11	2,670	19.79	5,227	7,704
NoReg (2024)	32.3	1,002	9.85	2,661	19.93	5,387	7,086
NoAll (2024)	32.9	1,030	10.07	2,600	19.80	5,111	8,306
NoSizeNoReg (2024)	33.0	1,032	10.04	2,599	19.71	5,102	8,225
NoRegNoSize (2024)	33.0	1,023	9.90	2,559	19.43	5,024	8,255

Source: Own calculations.

Table 5 shows farm size and payment per ha by scenario and simulation year for two major groups of regions: central regions (Eastern Lowlands, Lowlands in Central Norway, South-West Norway) and rural regions (Northern Norway, Western Norway, Southern Norway, Valleys in Eastern and Central Norway). The regional division is closely related to the shading of regions in Figure 3. Darker (lighter) shaded regions belong to rural (central) regions.

The average farm size in central regions is higher compared to rural regions, caused by differences in the type of production and natural conditions. Cereal farming is mainly located in central regions, and cereal farms are commonly larger than dairy farms or sheep farms, which are often located in more rural regions. In the baseline, average farm size increases more in central regions compared to rural regions. The impact of the scenarios on structural change for the two groups of regions is

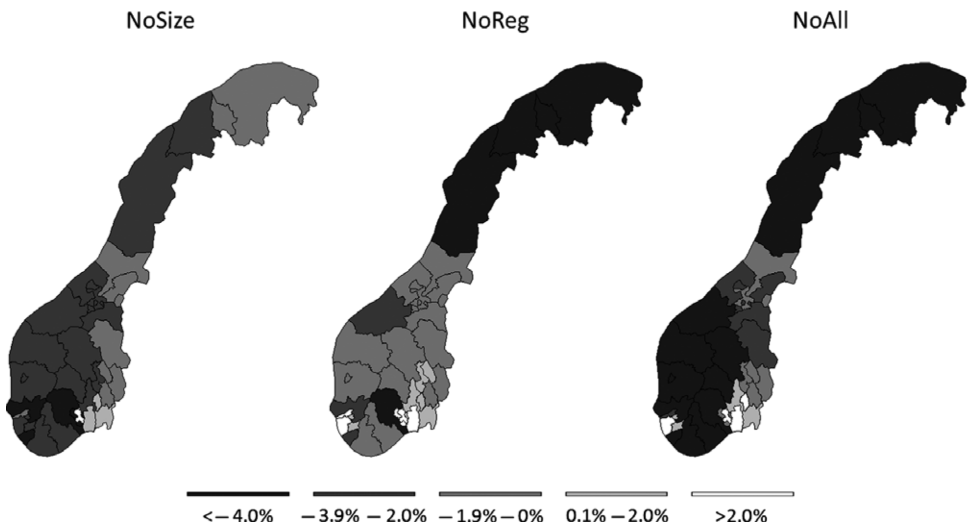

Figure 3. Percentage change land use per region for scenarios with immediate policy change compared to baseline in 2024

Table 5
Farm size and payments by region and policy scenario

Scenario and simulation year		Average farm size (ha)		Payment (€ per ha)	
		Central regions	Rural regions	Central regions	Rural regions
Baseline	2014	33.58	25.30	1,363	2,067
Baseline	2024	41.73	27.50	1,405	2,124
NoSize	2024	41.69	28.08	1,412	2,160
NoReg	2024	41.46	27.63	1,563	2,022
NoAll	2024	41.41	28.38	1,646	2,017
NoSizeNoReg	2024	41.80	28.30	1,646	2,008
NoRegNoSize	2024	41.70	28.35	1,643	2,012

Source: Own calculations.

ambiguous. In central regions, the removal of size-degressivity and regional differentiation has very little impact on average farm size, while size-degressivity increases the average farm size in rural regions, though marginally. An explanation for that result is found in the redistribution of payments induced by the scenarios. The abolition of both regional differentiation and size-degressivity boosts payments in the central regions. As a consequence, farm income increases in central regions reduces the probability of farm exit and leads to less structural change. The opposite is true for farms in rural regions. Here, payments decrease, reduce farm income and increase the probability of farm exit. Therefore, the increase in average farm size is bigger in rural regions compared to central regions.

6. Summary and Conclusions

We present a recursive-dynamic multi-commodity model, Agrispace, for Norwegian agricultural policy analysis covering 19 food and agricultural products, 32 regions and up to 16 aggregate farm clusters in each region derived from statistical analysis. The model uses explicit CES production functions and depicts competition for primary factors based on CET transformation functions and farm supply from the household to the farm. Agrispace is based on data on the entire farm population in Norway. That richness is maintained in simulations as payments are calculated annually for each single farm while production and input use at farm level are estimated from simulated results at farm cluster level. This allows the model to reflect the complex payment rules in Norwegian agricultural policy based on farm-size degressivity and regional differentiation of payment rates.

We apply the model to scenarios where payments are made partially or completely uniform, while total payments are kept constant with respect to activity levels in the base year. The policy reforms reshuffle profitability between types of production, geographical location and farm size and create second-order effects through adjustments at the farm level. Farm-size degressivity of payment rates has a larger impact on farm-structural change than the regional differentiation of payment rates. In addition, milk quotas at the county level prevent regional specialisation of dairy production. In this respect, the current policy regime seems to support the policy objective of maintaining a variety of farms in all parts of Norway.

The farm sector is far less affected by the analysed policy reforms at aggregate national level compared to regional level. There are two reasons for this. First, the reforms only redistribute farm support between farms and regions, but do not reduce the overall amount of support. Second, border protection remains unchanged in all scenarios. Overall, the results demonstrate the models' general ability to capture impacts of detailed payment regulations that depend on the characteristics of single farms. Moreover, the results indicate that those regulations indeed matter for the performance of the agricultural sector in general and structural change in particular. Hence, the main implication of this paper is to encourage the further development of models that, to the extent possible, build on single farm characteristics and combine these detailed data with the specification of markets for agricultural inputs and outputs.

The model results indicate that differences in the implementation of a policy reform may have farm-structural effects in the short run, but not necessarily in the long run. Since the model abstracts from (quasi-)fixed factor of production, adjustment processes at the farm level take place immediately – there is little time lag between the time of implementation and the time of adjustment. The timing of a policy reform is an important decision variable to policy-makers, in particular when policy reforms are costly and policy-makers may acquire new information as time goes by (Mittenzwei *et al.*, 2012). The model currently requires a full description of the payment system for all years between the base year and the final simulation year. An interesting avenue for future research would be to let the model update and adjust payments rates and eligibility criteria based on policy objectives, past performance of the agricultural sector and the economic framework conditions.

Structural change in the model is based on assumptions with regard to minimum profit levels depending on farm size and a stochastic component. The parameters of these thresholds are calibrated based on observed farm structural change in the past. Better knowledge about what drives farm exits in a Norwegian context and the relationship of farm exits to other farm variables would clearly improve the ability of the model to reflect the effects of policy reform on farm structural change.

Single farm data are available for Norway on a yearly basis back to 1999. Together with information on payments, these data allow us to assess the model's ability to simulate observed past farm structural change to validate the model and to improve its parameterisation. This constitutes another important avenue for future research.

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