EU-WIDE FARM TYPES SUPPLY IN CAPRI - HOW TO CONSISTENTLY DISAGGREGATE SECTOR MODELS INTO FARM TYPE MODEL

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Summary

The aim of the paper is to motivate the introduction and characterisation of an EU-wide farm type model in the CAPRI (Common Agricultural Policy Regional Impact) model, partly based on a comparison with other farm model approaches and to present the estimation approach necessary to achieve the disaggregation. The approach is based on an estimation which smoothly integrates the information from the EU-wide Farm Structure Survey (FSS) into the CAPRI model database. Example results from Denmark show that this approach outperforms simple scaling by uniform factors by endogenously taking information about the type of farming and economic size into account during the estimation.

Keywords: EU-wide farm supply analysis, highest posterior density estimator, CAPRI

1 Introduction

The Common Agricultural Policy (CAP) is evolving quickly, shifting its focus to externalities of agricultural production, provision of public goods and the contribution of the farming sector to Rural Development. The legally required impact assessments (EC, 2002) of EU legislation need to take these aspects into account, and the research community supports and accompanies the process of redirecting the CAP by developing and applying tools for impact assessment. The Common Agricultural Policy Regional Impact (CAPRI) model (BRITZ and WITZKE, 2008) provides a prominent example for such a tool used in different projects, such as in SEAMLESS (VAN ITTERSUM et al., 2008), SENSOR (JANSSON et al., 2007) or EURURALIS (VAN MEIJL et al., 2008), and impact assessments, e.g., for the Mid-Term Review (Britz et al., 2006) or the Sugar Market Reform (ADENÄUER, 2005, ADENÄUER et al., 2007). The development of CAPRI responded to the demand for regionalized analysis of a CAP moving from price- to direct income-support in the nineties, in order to complement the analysis of multi-commodity models with a country or EU resolution such as ESIM (BANSE et al., 2004) or AGLINK/COSIMO (OECD, 2007). Equally, environmental concerns were taken into account in CAPRI by integration of different environmental indicators such as nitrogen (LEIP et al., 2009) and GHG emission (PEREZ, 2005) accounting or a Life Cycle analysis of energy use in agriculture (KEMPEN and KRÄNZLEIN, 2008), recently improved by spatial downscaling (LEIP et al., 2008) and links to bio-physical models (BRITZ and LEIP, 2009).

However, as in many other economic models for the agricultural sector, CAPRI simulates for each region an aggregate of all farms. Such a territorial representation might lead to aggregation bias and does not allow analysis of impacts on specific farm groups. We motivate and discuss therefore in the following the development of a layer of farm type models for CAPRI, integrated in the overall model chain, and describe the development of a matching consistent data base. Section 2 motivates a disaggregation by farm types. It reviews existing farm type approaches and motivates and presents specificities of the CAPRI farm type layer. Section 3 discusses the definition of a suitable farm typology, where given regional data are disaggregated based on farm structural statistics. Section 4 introduces details of the disaggregation problem. Section 5 presents data and data preparation. Section 6 shows results for an example region and conclusions are drawn and the approach critically discussed in Section 7.

2 The Farm Type Approach

2.1 Motivation of farm type models in the impact assessment of agricultural policies

Disaggregation by farm type mainly aims to capture heterogeneity in farming practises and farms within a region, in order to reduce aggregation bias in response to policy and market signals, with a focus on farm management, farm income and environmental impact. The argument is especially striking when policy instruments are either targeting specific farm types or are modulated depending on farm characteristics. The evolvement of the accompanying measures in the 1992 reform, and the introduction of premium schemes depending on farm characteristics, such as stocking densities and herd sizes, the small producer scheme and agri-environmental legislation such as the Nitrate and Water directives generated an incentive for tools and analysis disaggregated by farm types. Examples are the AROPAj system (BARANGER et al., 2008), FARMIS (OFFERMANN et al., 2005) and LUAM (JONES et al., 1995) where aggregates of specific farm types for administrative regions at the sub-national scale are simulated based on mathematical modelling and sources by the European Farm Accountancy Data Network (FADN) database, so called bio-economic farm models such as the FFSIM model in SEAMLESS (LOUHICHI et al., 2009) or econometrically estimated farm-household models (see, e.g., LANSINK and PERLING, 1996).

Besides the reduced aggregation bias, a dis-aggregation by farm types in impact assessment contributes results regarding the distribution of impact in the farming community, e.g., regarding farm income distribution, environmental externalities or provision of public goods. It might also allow linkage to modules for farm structural change.

2.2 Review of existing approaches

The comparison presented in the following section aims at emphasizing differences between the three different approaches to farm type models, to better motivate the specific layout chosen for the CAPRI farm type layer. The *first* approach is based on linear or non-linear programming models representing either single farms or groups of farms defined from FADN or similar sources at national or regional level. FADN, based on micro-accounting data, provides output coefficients such as crop yields, the selection of production activities, and resource capacities such as land or family labour as well as output prices. Input coefficients, such as fertiliser application rates or feed requirements per production activity, are not provided by FADN, and therefore typically derived based on engineering approaches or are econometrically estimated. The input and outputs coefficients, along with related prices define gross margins per production activity. The objective function maximizes the sum of these gross margins by choosing an optimal farm program, depending on the resource endowment and resource requirements at activity level. The basic methodology focuses on currently observed farming practices, as the production possibility set is derived from FADN. However, compared to CAPRI, where a non-linear cost function is introduced and where possible econometrically estimated (JANSSON, 2007), AROPAj and LUAM, as many linear programming models, face well-known problems of Linear Programming (LP) such as overspecialization and jumpy behaviour. Therefore, additional safeguards such as maximum cropping shares or bounds on the allowed changes of herd sizes are introduced in the framework. The calibration of the AROPAj model to the observed praxis (DE CARA and JAYET, 2000), unlike in CAPRI or FARMIS, does not result in an exact but in approximated calibration by adjusting uncertain I-O parameters to reduce the gap between the observed cropping patterns and the computed solution. The approaches based on FADN will inherit its properties, specifically, its relatively low representation of less frequent farm types.

The *second* approach is more normative as a far wider range of potential activities defines the solution space of the model, derived from combining engineering knowledge with simulations by biophysical models. An example is provided by the farm models in the SEAMLESS modelling chain (LOUHICHI et al., 2009). The farm endowment, such as family labour, land or production rights might be taken from FADN, and the observed yields may serve as an indication of potential yields, but linking the potential choice set characterizing the farms to the observed one and the given endowment requires expert knowledge. The model set-up is hence far more resource-demanding than using solely observed practise from FADN. Primary data collection and link to GIS is necessary to source the bio-physical models, including location specific data relating to soil, topology, climate or the crop calendar. As a consequence, even a large-scale project such as SEAMLESS only populated some EU regions with models, supposed to be representative, and used statistical extrapolation to generate results for the whole EU. For a more detailed comparison of FSSIM to CAPRI, see (BRITZ et al., forthcoming). Calibration to the observed current state of the system, but even more, to observed responses of the farming systems to changes in its market and policy environment remains a challenge in bio-economic model and is a partially unresolved issue, as is their application for forward looking analysis where technical progress need to be taken into account. Bio-economic models are however suitable to highlight which potential activities might be chosen by farmers under a different policy and market environment. And clearly, their detailed description of agricultural management eases linkage to environmental indicator calculators or bio-physical models, and allows simulation of such policy measures linked to very specific farm management practises.

The *third* approach rests in econometrically estimated farm-household models. Requiring panel data or even cross-sectional time series, they are mostly based on FADN or, again, based on often richer national and regional farm record data sets. Prominent examples are different variants of such models estimated by LANSINK and PERLING (1996). Based on duality theory, utility or profit maximization is assumed to derive behavioural functions representing first order conditions, where parameter restrictions and/or the choice of the functional form guarantee regularity. Their biggest advantage lies in their fully empirically based simulation behaviour, and their ability to test for the underlying behavioural assumptions. However, the often highly non-linear estimators restrict the size of the parameter space, leading typically to a far higher aggregation by activities/products compared to the programming approaches discussed above. A further serious disadvantage of these duality based models for integrated assessment is the missing explicit technology description where input demands can typically not be allocated to activities. That renders it difficult to link their results to bio-physical accounting approaches or models.

2.3 Characteristics of the farm types in CAPRI and selection procedure

Perhaps the most important characteristic of the CAPRI farm type module is its full integration in the CAPRI modelling chain, which ensures price feedback based on sequential calibration with the global, large-scale market model (BRITZ, 2008). All the other approaches discussed above are stand-alone supply models, where prices are exogenous. Linking these other farm models to existing market models is far from easy due to differences in product definitions, but also, due to the missing match to the data sets underlying market models, questions of IT integration notwithstanding. The strict and consistent top-down disaggregation approach in CAPRI discussed in the following ensures a harmonized data set across regional scales and farm types.

The farm type supply module in CAPRI consists of independent aggregate non-linear programming models for each farm type and each region, representing as an aggregate all activities of all farms falling in that type and a specific administrative regional unit at NUTS II level. As templates, they share the structure of the regional programming models in CAPRI and thus provide a compromise between a pure LP approach and the fully econometrically estimated one. The latter is achieved by combining a Leontief technology for variable costs covering a low and high yield variant for the different production activities with an in part econometrically estimated non-linear cost function (JANSSON, 2007), extending Positive Mathematical Programming (PMP) (HOWITT, 1995). The cost function captures the effects of labour and capital on farmers' decisions and allows both for perfect calibration of the models and a smooth simulation response. The farm models capture, similar to the regional ones, in high detail, the premiums paid under the CAP, include NPK balances and a module with feeding activities covering nutrient requirements of animals. Constraints besides the feed block relate to arable land and grassland, set-aside obligations and milk quotas. Prices are exogenous in the supply module and provided by the market module, with whom they are solved sequentially until convergence. Grass, silage and manure are assumed to be non-tradable and receive internal prices based on their substitution value and opportunity costs.

The CAPRI farm type module comprises a maximum of ten farm types per region, which always include a residual farm type to exhaust regional production as well as input and primary factor use. Each of the remaining up to nine farm groups is characterized by the "type of farming," see Table 1, defined by the relative contribution of different production branches to the gross margin of the farm (EUROPEAN COMMISSION, CD 85/377/EEC, Article 6), and the "economic size class" based on "European size units" (ESU)[1], a concept defined in Chapter IV Article 8 in CD 85/377/EEC and Annex III. The EU classification scheme allows for a far more detailed characterisation of the farm's specialisation, but data confidentiality issues and reduced average weights when using more disaggregated types on regional aggregates render it suitable to stick to the classification shown below. Equally, resources for reporting and result analysis clearly depend on the level of disaggregation. Similar arguments hold to allow for solely three farm size classes, leading to 14*3=52 cells in overall typology.

Table 1: Type of Farming groups in CAPRI

CAPRI farm type index	Type of farming FSS	Long text for the CAPRI farm type
1	FT13	Specialist cereals, oilseed and protein crops (FT 13)
2	FT14_60	General field cropping (FT 14) + Mixed cropping (FT 60)
3	FT41	Specialist dairying (FT 41)
4	FT_42_43	Specialist cattle-rearing and fattening (FT 42) + Cattle-dairying, rearing and fattening combined (FT 43)
5	FT44	Sheep, goats and other grazing livestock (FT 44)
6	FT50	Specialist granivores (FT 50)
7	FT7	Mixed livestock holdings (FT 7)
8	FT8	Mixed crops-livestock (FT 8)
9	FT31	Specialist vineyards (FT 31)
10	FT32	Specialist fruit and citrus fruit (FT 32)
11	FT33	Specialist olives (FT 33)
12	FT34	Various permanent crops combined (FT 34)
13	FT2	Specialist horticulture (FT 20)
14	FT9	Non-classifiable holdings'

The restriction to maximal ten farm groups per region is based on storage and computing time considerations, but also by the aim to keep database and model outputs at a manageable size for quality control and result analysis. Those farm groups, differentiated by the typology based on size and specialisation, which are represented explicitly in a region are selected according to their importance for the regional agriculture measured by Livestock Units (LU) and Utilised Agricultural Area (UAA). Compared to weights based on number of farms or economic indicators, area farmed and livestock numbers provide a compromise between

[1] The following size classes had been chosen: <1-<16 ESU, 16-<100 ESU, 100< ESU

economic, social and environmental aspects of farming. Applying the methodology to all NUTS II regions in the EU leads to the distribution as depicted in Table 2.

Table 2: General overview of farm types selected for the CAPRI layer

	No. of types in				
	EU-27	**EU-25**	**EU-15**	**EU-10**	**EU-02**
A Economic size					
< 16 ESU	541	464	321	143	77
≥ 16 ≤ 100 ESU	715	698	628	70	17
> 100 ESU	460	440	346	94	20
B Type of Farming					
Specialist cereals, oilseed and protein crops (FT 13)	237	212	149	63	25
General field cropping (FT 14) + Mixed cropping (FT 60)	290	271	212	59	19
Specialist horticulture (FT 20)	9	9	9		
Specialist vineyards (FT 31)	9	9	9		
Specialist fruit and citrus fruit (FT 32)	16	16	14	2	
Specialist olives (FT 33)	18	18	18		
Various permanent crops combined (FT 34)	13	13	13		
Specialist dairying (FT 41)	239	230	200	30	9
Specialist cattle-rearing and fattening (FT 42) + Cattle-dairying, rearing and fattening combined (FT 43)	168	168	152	16	
Sheep, goats and other grazing livestock (FT 44)	194	172	159	13	22
Specialist granivores (FT 50)	118	108	76	32	10
Mixed livestock holdings (FT 7)	103	89	56	33	14
Mixed crops-livestock (FT 8)	302	287	228	59	15
C Residual farm type					
Residue	225	211	170	41	14
Total (A+C or B+C)	1,941	1,813	1,465	348	128

3 Disaggregation Problem

The disaggregation of the regional data base of CAPRI to farm types delivers specific benefits, which relate to the existing infrastructure of CAPRI. The farm type module shares the structure and technical implementation of the regional database, allowing use of existing procedures to populate and calibrate the individual farm models, and to store and view results. Equally, all existing post-model reporting modules for the regional model can be applied, such as indicator calculators for nutrient balances and green house gases accounting. Once the results from the farm type are re-aggregated to the NUTS II level, they can be down-scaled to an 1x1 km resolution (LEIP et al. 2008). The top-down data consistency integrates the farm type models smoothly in the overall system, ensuring also their inter-operability with the global market model.

For consistency, however, harmonization of the production levels found in the Farm Structure Survey (FSS) data with the regional data base of CAPRI is required, a major challenge, also from the methodological viewpoint, which is discussed in detail in the next section. We refrain here from discussing how a the full farm type data base is constructed, including mutually compatible input and output coefficients, see GOCHT (forthcoming) for a discussion.

The FSS delivers data on production levels, providing a well-established statistical database, harmonized across Europe and featuring suitable coverage by farm type. Despite that fact that

FSS underlies many of the regional statistics sourcing CAPRI, some inconsistencies to the regional data set in CAPRI remain. This is the case because:

- CAPRI considers a three year average (for the version discussed here years 2001-2003) derived from regional time series, whereas FSS provides data for one specific year from the period 2003 – 2005, depending on the Member State.
- The regional CAPRI database is made consistent to national data sets such as market balances and economic accounts, completed such that data gaps have been filled in by means of econometric routines, and harmonized over time regarding product/activity classifications. As a consequence, regional data in CAPRI can differ slightly from annual FSS data.
- The economic thresholds for the FSS survey are different from those underlying the Economic Accounts for Agriculture (EAA). This can lead to inconsistencies for some selected activities such as nurseries where production quantities are not defined in physical units but in constant values.
- All figures in FSS are rounded to the first digit after the comma and those individual farm data which account for more than 80 percent of the aggregate are replaced by missing values, as outcome of EU legislation dealing with statistical confidentiality (Council Regulations (CE) No. 322/97, OJ No L 52/1, and EURATOM, EEC No. 1588/90, OJ No L 151/ 1).

One way to remove the data inconsistencies in acreage and herd sizes consists in multiplying each FSS value with a fixed correction factor, calculated from the given regional value in CAPRI and the sum over the farm types in that region in FSS. However, this can first lead to a correction of the activity levels which changes the farming pattern such that a different type of farming or a different ESU classification could result for some farm groups, so the data base might no longer represent the most important groups according to FSS. Secondly this approach could also result in a violation of political requirements for set-aside in the FSS groups[2]. Not least, the changes could generate unrealistic farm programs. In order to avoid reclassifications during the consistent top-down disaggregation, we propose a statistical estimator which ensures regional consistency and compliance with set-aside obligations while preventing changes in the type of farming and economic size class. The estimator treats the original FSS farm group data as a random variable comprising measurement errors, which seems reasonable given rounding, introduction of missing values and reporting thresholds. By assuming properties of the error distribution, the most probable crop levels and acreages for each farm type are estimated recovering the given regional data, in compliance with set-aside obligation while maintaining the type of farming and ESU class of each farm group.

4 The statistical disaggregation estimator

The following section will discuss in some detail the layout of the disaggregation estimator, starting with the data constraints, before the definition of the Highest Posterior Density is motivated.

4.1 Data constraints

The estimator aims first at ensuring that each farm group keeps its "type of farming" (see Table 2) during estimation, which requires translation of tabular information in official documents (EUROPEAN COMMISSION, CD 85/377/EEC, Annex II Section B) in numerical

[2] The farm type base year is referenced to a three year average around 2002. Therefore set-aside was still in place and had to be considered.

constraints. Specifically, the “type of farming” is defined by rules relating to the contribution of production branches, expressed by the partial standard gross margins (SGM) (**p**), in relation to the total SGM (**t**). Both, the partial and the total SGM are expressed in Economic Size Units (ESU). **t** and **p** of a farm group is determined by a set of standard coefficients (**s**) which can be used to value areas under crops and numbers of animals produced by the farm groups, where it is assumed that one ESU is worth 1.200 Euro.

During the estimation, these contribution of production branches shares are not allowed to violate a set of constraints, similar to crop rotation restrictions, which define the given farm type. The total standard gross margin (**t)** is a (1 x F) vector and therefore computed by

(1) $\mathrm{t} = (\sum_{j} \mathrm{s}_j \mathrm{x}_j) / (1200 \times N) \ \ \forall\ \mathrm{f} \in \mathbf{F}$

for each farm group (f) where N is the number of holdings represented by the particular farm group (f) and 1.200 indicates the value of one ESU. The matrix (x), for each region in CAPRI, consists of a farm type dimension with f=1,.., F and of a production activity dimension with j=1,.., J indicated in Annex Table A1 and holds the production levels in ha or heads to be estimated. The vector (s) is the activity specific gross margin in Euro given per ha or head and provided by Eurostat[3] for each sub-region. Constraints had been defined for all types according the rules outlined in EU Commission (CD 85/377/EEC), and ensure during estimation of the production levels (x) that the selected types stay within their definition. To give an example the type of farming which comprises specialized cereals, oilseed and protein crops have two constraints which are implemented in the estimation problem as:

(2) $((\sum_{j \in \mathrm{P1}} \mathrm{s}\,\mathrm{x}) / 1200) / \mathrm{t} > 2/3 \ \ \forall \mathrm{f} \in \mathbf{F}$

(3) $((\sum_{j \in \mathrm{P13\_14}} \mathrm{s}\,\mathrm{x}) / 1200) / \mathrm{t} > 2/3 \ \ \forall \mathrm{f} \in \mathbf{F}$

The constraints which ensure that the farm groups remain in the ESU size class are for the smallest size class with less than 16 ESU

(4) $\mathrm{t} < 16 \ \ \forall \mathrm{f} \in \mathbf{F}$

for the size class greater equal than 16 and less than 100 ESU as

(5) $\mathrm{t} \geq 16 \ \cap\ \mathrm{t} < 100 \ \ \forall \mathrm{f} \in \mathbf{F}$

and for the large scale farm size class as

(6) $\mathrm{t} \geq 100 \ \ \forall \mathrm{f} \in \mathbf{F}$

A further restriction defines the obligatory set-aside area as a function of the Grandes Cultures Area as:

(7) $\mathrm{x}_{oset} = \sum \mathrm{x}\,\mathrm{q} / (100 - \mathrm{q}) \ \ \forall \mathrm{f} \in \mathbf{F}; \forall\, \mathrm{j} \in \mathbf{A}$

The crop production activities for arable land are (A) with $\mathrm{A} \subset \mathrm{J}$. The set-aside rate (**q**) is given for each crop in percentage. The next constraint ensures that for each production activity, the sum of all farm types sums up to the regional levels indicated by (r)

(8) $\sum_{f \in \mathrm{F}} \mathrm{x}_f = \mathrm{x} \ \ \forall\, \mathrm{j} \in \mathrm{J}; \forall \mathrm{r} \in \mathrm{R}$

and the last equation calculates the UAA (**u**) for each farm type.

(9) $\sum_{j \in \mathrm{J}} \mathrm{x}_j = \mathrm{u} \ \ \forall \mathrm{f} \in \mathrm{F}$

[3] The SGM are collected by EUROSTAT from the MS and are downloadable from the official EUROSTAT webpage. The special method for grazing stock and fodder crops is implemented in the CAPRI farm type approach (see CD 85/377/EEC, Annex I, 5. treatment of special cases).

4.2 Estimator

The data constraints alone do not allow a unique solution to be found, as there are the F * J unknown vectors of cropping hectares and animal herd sizes ($\mathbf{x}$) to be estimated, which by far exceed the number of linear (in)equality constraints. The FSS raw data on cropping acreages and animal herd sizes are therefore seen as random variables distributed around the true, but unknown observations which are characterised by the above defined data constraints. We assume that the error term is white noise with co-variance zero, and follow the approach in HECKELEI et al. (2008) to derive a Highest Posterior Density estimator to recover the data with the highest posterior density. That leads to the following estimator

$$(10)\quad \begin{aligned} &\min\ vec(\mathbf{x}-\mathbf{x}^{\mathrm{p}},\mathbf{u}-\mathbf{u}^{\mathrm{p}},\mathbf{p}^{\mathrm{n}}-\mathbf{p}^{\mathrm{n,p}},\mathbf{t}-\mathbf{t}^{\mathrm{p}})' \\ &\times\Sigma^{-1}\, vec(\mathbf{x}-\mathbf{x}^{\mathrm{p}},\mathbf{u}-\mathbf{u}^{\mathrm{p}},\mathbf{p}^{\mathrm{n}}-\mathbf{p}^{\mathrm{n,p}},\mathbf{t}-\mathbf{t}^{\mathrm{p}}) \end{aligned}$$

where the partial standard gross margin ($\mathbf{p}$) is defined as:

$$(11)\quad \mathrm{p}^{\mathrm{n}} = (\sum_{j\in P_{\mathrm{n}}} \mathrm{sx})/1.200\ \forall \mathrm{f}\in\mathbf{F};\ \mathrm{n}\in 1..5,$$

and n indicates a sub-sample of production activities as defined in Annex table A1. The estimation framework combing the estimator and the data constraints can be interpreted as the search for the production activity levels which minimize the deviation between the prior information on levels $\mathbf{x}^{\mathrm{p}}$, on total standard gross margins $\mathbf{t}^{\mathrm{p}}$, the partial standard gross margins $\mathbf{p}^{\mathrm{p}}$ and the UAA $\mathbf{u}^{\mathrm{p}}$ of each farm group with respect to the constraints for each farm type in the region for the Type of Farming and the Economic Size, the set-aside regulations (political constraints) and the consistency to regional data.

5 Databases underlying the consistent EU-27 wide farm types approach

One outstanding attribute of the farm type layer in CAPRI is its EU-27 wide territorial coverage. Only two harmonized and standardized data sources provide information on farm types at the EU-27 level: FADN and FSS. FADN is the most often used database to source EU farm type models. It comprises single farm record data on production and sales quantities, production activity levels, yields for selected activities, input cost aggregated on the farm level; information about prices and positions of the gain and loss accounts of a farm plus some further elements. The definitions in FADN are harmonized by EU legislation which also requests yearly updates by the EU Member States. The second data source, the Farm Structure Survey (FSS), reports mainly data on production activities by region and farm type, based on a sub-survey each third year and a complete survey each tenth year. Both data sets exclude small farms based on minimum economic thresholds, with lower thresholds in FSS and a hence better representation compared to FADN. Eurostat[4] aggregated and processed the single FSS records for all ~250 CAPRI regions for EU-27, according to the chosen typology, delivering a data set respecting the data confidentiality obligations mentioned above. Farm groups were deleted, where after rounding, the UAA levels or the number of holdings were zero. The data set covers data on land use, livestock farming and labour force as well as number of farms for each farm type and region. The example results presented here refer to Denmark, with 36 farm non empty groups by specialisation and size class, and any remaining groups in the FSS aggregated to a residual farming group. Rounding and introduction of missing values due to statistical confidentiality obligations might lead to cases where the prior data are not in line with the type of farming and the ESU class shown in the data set. Therefore, the type of farming and the ESU class for each raw FSS group are re-calculated in

[4] The work of Pol Marquer from EUROSTAT is gratefully acknowledged. He extracted different data selections for the new farm type layer and supported the whole data selection process with his knowledge and expertise.

order to apply the correct constraints of the raw data during estimation and to obtain the correct partial SGM and the TSGM.

6 Results

In order to analyse to what extent the proposed estimator leads to an improved presentation of the farming structure, the results are compared to a fixed number-scaling. Table 3 reports the results for the partial SGMs P1, P4 and P5[5] per farm type for Denmark. It can be seen that lower deviations from the prior shares in FSS could be achieved, compared to applying a uniform correction factor for each production activity.

Table 3: Priors for and estimated partial SGMs (P1-P5) for all farm type in Denmark

Type of farming	Economic Size Class	partial SGMs P1 FSS	P1 Scaling	P1 Deviation	P1 Estimation	P1 Deviation	P4 FSS	P4 Scaling	P4 Deviation	P4 Estimation	P4 Deviation	P5 FSS	P5 Scaling	P5 Deviation	P5 Estimation	P5 Deviation
	Unit	share	share		share		share	share		share		share	share		share	
Specialist cereals, oilseed and protein crops (FT 13)	≥ 16 and ≤ 100 ESU	0.94	0.93	-2%	0.94	0%	0.04	0.06	29%	0.04	0%	0.02	0.02	-1%	0.02	0%
Specialist cereals, oilseed and protein crops (FT 13)	> 100 ESU	0.94	0.94	-1%	0.94	0%	0.02	0.02	21%	0.02	0%	0.04	0.04	5%	0.04	0%
General field cropping (FT 14) + Mixed cropping (FT 60)	≥ 16 and ≤ 100 ESU	0.88	0.87	-1%	0.88	0%	0.06	0.08	24%	0.06	0%	0.03	0.03	-8%	0.03	0%
General field cropping (FT 14) + Mixed cropping (FT 60)	> 100 ESU	0.86	0.86	-1%	0.86	0%	0.02	0.03	30%	0.02	0%	0.06	0.07	6%	0.06	-1%
Specialist dairying (FT 41)	≥ 16 and ≤ 100 ESU	0.29	0.33	12%	0.29	-1%	0.71	0.66	-7%	0.71	0%					
Specialist dairying (FT 41)	> 100 ESU	0.27	0.30	11%	0.27	-2%	0.73	0.70	-5%	0.72	1%					
Specialist granivores (FT 50)	> 100 ESU	0.22	0.21	-5%	0.22	0%						0.78	0.79	1%	0.78	0%
Mixed crops-livestock (FT 8)	≥ 16 and ≤ 100 ESU	0.56	0.54	-4%	0.57	0%	0.17	0.22	22%	0.17	3%	0.26	0.24	-11%	0.27	-2%
Mixed crops-livestock (FT 8)	> 100 ESU	0.50	0.48	-4%	0.49	1%	0.04	0.05	16%	0.04	1%	0.46	0.47	2%	0.46	-1.6%

Source: own calculation

Table 4: Priors for and estimated UAA and ESU for all farm type in Denmark

Type of farming	Economic Size Class	ESU FSS	ESU Scaling	ESU Deviation	ESU Estimation	ESU Deviation	UAA FSS	UAA Scaling	UAA Deviation	UAA Estimation	UAA Deviation
	Unit	ESU	ESU		ESU		1,000 hectare	1,000 hectare		1,000 hectare	
Specialist cereals, oilseed and protein crops (FT 13)	≥ 16 and ≤ 100 ESU	36.7	35.1	-4%	36.4	-1%	446.7	433.8	-3%	459.5	3%
Specialist cereals, oilseed and protein crops (FT 13)	> 100 ESU	190.8	172.1	-11%	189.2	-1%	231.6	217.7	-6%	243.8	5%
General field cropping (FT 14) + Mixed cropping (FT 60)	≥ 16 and ≤ 100 ESU	43.7	45.2	3%	43.7	0%	223.9	234.9	5%	229.6	2%
General field cropping (FT 14) + Mixed cropping (FT 60)	> 100 ESU	225.5	205.3	-10%	222.8	-1%	325.7	312.2	-4%	331.4	2%
Specialist dairying (FT 41)	≥ 16 and ≤ 100 ESU	82.0	95.7	14%	84.1	2%	68.1	83.8	19%	67.0	-2%
Specialist dairying (FT 41)	> 100 ESU	249.0	283.1	12%	258.3	4%	349.8	451.8	23%	368.5	5%
Specialist granivores (FT 50)	> 100 ESU	328.7	319.7	-3%	331.1	1%	159.5	152.7	-4%	170.8	7%
Mixed crops-livestock (FT 8)	≥ 16 and ≤ 100 ESU	49.3	53.9	9%	50.3	2%	109.7	115.4	5%	115.1	5%
Mixed crops-livestock (FT 8)	> 100 ESU	244.0	229.3	-6%	236.1	-3%	394.5	376.2	-5%	410.7	4%
Aggregated residue							354.5	388.9	9%	371.1	4%

Source: own calculation

[5] Partial SGM P2 and P3 are not identified or very small for the selected farm types because those partial standard gross margins belong to farming types not identified in the case of Denmark.

Table 4 presents a comparison between the prior, the scaling method and the estimated values for the economic size of the farm type (ESU) and its land endowment (UAA). Again, the estimator outperforms simple scaling, leading to lower correction of total area and Economic Size of the farm groups.

Table 5 presents the deviation of crop groups for the different farm types in Denmark. Two aspects are worth commenting upon. Firstly, the deviation for the residual farm type is larger than for the other farm types. The reason is the missing rule for the residual farm type. The deviations of farm types with a clear definition regarding specialization and economic size are less prone to deviations as changes are restricted by the constraints which define farm size and farm specialization. Secondly, small observations are less robust and the percentage deviation can be higher, as for example, rounding has a far stronger effect.

7 Discussion and conclusions

The paper motivated the introduction of a farm type layer in the CAPRI model, compared it to alternative solutions and addressed the issue of a consistent disaggregation of regional agricultural data by farm supply. We will first discuss the latter issue.

Consistent disaggregation problems are frequent in economic analysis when working simultaneously on different spatial scales or combining different data sets. Our example provides a solution when structural relations at the lower level need to be maintained, here relating to the characterization of farm size and farm specialization. Examples for similar problems are the estimation of land cover or areas in a spatial disaggregation exercise, where one would like to keep cover and crop share relations in certain bounds at lower spatial scales, or the estimation of I/O coefficients consistent to national accounts while maintaining cost shares from the original micro records.

We propose the application of a Bayesian motivated estimation framework which treats the available disaggregated information, here the FSS data, as a random variable. Whereas the disaggregated data provide prior information, consistency and definition based conditions provide the data information. Their combination provides posterior estimates which fulfil the top-down disaggregation requirement while exhausting the information content of the raw data. In our example, the estimator ensures that the type of farming of each group, as well as the economic size of a farm group were not violated, allowing for a consistent disaggregation of the CAPRI regional data base based on the FSS database of Eurostat to source a layer of farm type models. The main aim of introducing farm types into the CAPRI model was to improve policy impact assessments by considering farm structural characteristics such as farm size, crop mix, stocking density and yields, in order to considerably reduce aggregation bias and thus to improve the reliability of regional results. But equally, income effects as well as environmental and social impacts can be analysed in the context of farm specialization and size.

What are the down sides of the CAPRI farm type approach? First of all, the use of stylised and relatively simple template models which are structurally identical and express differences between farm type and regions solely by parameters alone might fall short of capturing the full diversity of farming systems in Europe. In particular, the evaluation of policy measures which impact on farm management decisions, such as manure handling or feeding practices, demand models which comprise these as decision variables. The relatively simple representation of agricultural technology in CAPRI compared to approaches parameterised based on biophysical models narrows down the scope of extensions in that direction, albeit the potential of the current template is not yet fully exploited in CAPRI. However, the dichotomy between increased detail for specific activities, regions and farm types, and a structurally identical template model remains.

Table 5: Estimates for selected crop activity level in Denmark

Type of farming	Economic Size Class	Ceareals					Pulses, Potato and Sugar Beet					Fodder Crops and Gras					Set-aside				
		FSS	Scaling	Deviation	Estimation	Deviation	FSS	Scaling	Deviation	Estimation	Deviation	FSS	Scaling	Deviation	Estimation	Deviation	FSS	Scaling	Deviation	Estimation	Deviation
	Unit hectare	1,000	1,000		1,000		1,000	1,000		1,000		1,000	1,000		1,000		1,000	1,000		1,000	
Specialist cereals, oilseed and protein crops (FT 13)	≥ 16 and ≤ 100 ESU	322	320	-0.6%	330	2.5%	13	15	15.1%	12	-3.9%	31	38	17.8%	67	53.7%	45	38	-17.8%	36	-26.1%
Specialist cereals, oilseed and protein crops (FT 13)	> 100 ESU	164	159	-2.7%	165	0.6%	7	8	10.7%	7	-7.4%	11	12	13.6%	24	55.9%	20	18	-7.2%	21	5.6%
General field cropping (FT 14) + Mixed cropping (FT 60)	≥ 16 and ≤ 100 ESU	105	106	0.6%	105	0.5%	19	19	0.7%	19	-1.4%	65	84	22.4%	77	15.3%	17	14	-22.3%	16	-9.4%
General field cropping (FT 14) + Mixed cropping (FT 60)	> 100 ESU	183	181	-0.9%	180	-1.4%	52	50	-2.8%	53	3.3%	28	35	18.9%	52	45.8%	28	22	-29.2%	22	-30.9%
Specialist dairying (FT 41)	≥ 16 and ≤ 100 ESU	16	17	2.9%	16	0.1%						47	63	25.5%	46	-1.9%	4	3	-23.4%	4	9.3%
Specialist dairying (FT 41)	> 100 ESU	73	74	0.3%	78	5.4%	3	3	-0.1%	8	59.0%	239	355	32.6%	265	9.9%	28	17	-70.2%	17	-67.2%
Specialist granivores (FT 50)	> 100 ESU	119	117	-1.7%	121	1.9%	2	2	2.4%	2	-11.4%	8	9	13.1%	14	41.5%	12	12	6.9%	15	22.6%
Mixed crops-livestock (FT 8)	≥ 16 and ≤ 100 ESU	66	66	-0.2%	67	2.0%	2	2	7.5%	2	-5.8%	29	37	21.8%	31	7.8%	7	7	0.5%	9	21.5%
Mixed crops-livestock (FT 8)	> 100 ESU	275	269	-2.3%	280	1.7%	15	15	2.2%	11	-35.7%	29	34	13.8%	64	54.2%	31	30	-3.9%	26	-18.1%
Aggregated residue		167	170	1.3%	135	-24.2%	4	4	9.1%	6	33.2%	140	169	17.3%	195	-20.9%	17	25	31.7%	21	-46.4%

Source: own calculation

Updating and maintaining a regional data base with an additional breakdown by farm types requires more resources, as does the application of the enlarged simulation tool.

The CAPRI farm type layer provides a complementary approach to alternative farm type approaches. Its strength rests firstly in the fact that harmonized data sources and assumptions are applied across Europe; secondly, that the layer is transparently linked with a complex agricultural trade model so that the full range of CAP measures and their interactions can be analyzed; thirdly, that its maintenance and application are cheaper compared to alternative approaches should one aim at a full coverage of the EU.

A possible drawback of opting for a disaggregation by farm type instead of increasing the spatial resolution of the model is the fact that farm groups are not spatially explicit. That renders a link to bio-physical models challenging as, e.g., the soils on which the farm groups operate are not known. However, economic theory suggests that the distributional moments of bio-physical attributes as soil, slope, surrounding land cover or climate for each farm type will differ from the regional aggregated ones. Some approaches therefore try a spatial distribution of farm groups (see, e.g., ELBERSEN et al., 2006).

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