Farm Level Impacts of Trade Liberalisation and CAP Removal Across EU: An Assessment using the IFM-CAP Model

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Abstract

This paper assesses the farm-level impacts of trade liberalisation and CAP removal across EU using IFM-CAP (Individual Farm Model for CAP Analysis). IFM-CAP is a static positive programming model developed to capture the full heterogeneity of EU farms in terms of feedback to policy representation and impacts. Simulation results show that a small set of farm-types experience an increase in income due to the improvement in prices and yields (e.g. farms specialised in granivores, milk and horticulture), while farms that are most CAP subsidy dependent (e.g. specialist cattle, specialist COP and small farms) lose income by more than 12% at aggregate EU level. As much as 77% of all farms lose income if CAP is removed, while the proportion of most income vulnerable farms almost doubles.

Key Words

Common Agricultural Policy; farm model; Positive Mathematical Programming; direct payments; EU-wide; FADN (Farm Accountancy Data Network)

1 Introduction

In the recent years there has been a lively debate among policy makers, stakeholders and academics on the future of the Common Agricultural Policy (CAP). Several on-going events at both EU (e.g. *Brexit*) and global (e.g. migration, food security) scale have put the CAP under pressure for further reform. Given that the CAP budget represents a significant share of the total EU budget (37% in 2017), these developments are expected to reduce the available financial resources for the CAP. For example, since the UK is a net contributor to the EU budget, *Brexit* is expected to potentially reduce the CAP budget. Further, the concerns about migration and global security may divert EU resources to these priorities to the detriment of the CAP. Reflecting on these developments, European Commission proposed up to 30% cut of the CAP budget in the EU Multi-Financial Framework after 2020 (EUROPEAN COMMISSION, 2018b).

Apart from the pressures on the CAP budget cut, there is an intensive on-going debate about the effectiveness of direct payments[1] – which represent the main bulk (72%) of the CAP expenditures – in addressing policy objectives such as farmers' income support. First, there is concern that an excessive share of direct payments benefits big farms,[2] largely driven by the allocation mechanism of direct payments which is based on land area (MATTHEWS, 2017; European Commission, 2017). Second, a substantial share of direct payments could be leaked to landowners instead of farmers because of their capitalization into higher land values. Empirical studies show that the share of direct payments potentially leaked to landowners could be greater than 20% (e.g. KILIAN *et al.*, 2012; VAN HERCK et al., 2013; MICHALEK et al,, 2014; O'NEILL and HANRAHAN, 2016; KLAIBER et al., 2017; CIAIAN et al., 2018). These income distributional issues pose the question whether and how actual farmers depend on CAP, and more especially on direct payments, and what are their degree of vulnerability to potential CAP budget reduction or elimination (KIRYLUK-DRYJSKA and BAER-NAWROCKA, 2019).

These CAP pressures raise the question of the extent to which the EU farming sector would be affected by a radical CAP reform. We address this question by analysing the implications for the EU farming sector of a scenario which assumes a complete abolition of CAP, including both direct payments and Rural De-

[1] Under the current CAP, the direct payments include decoupled payments (66%) (Basic Payment Scheme or Single Area Payment Scheme), redistributive payment (4%), Voluntary Coupled support (10%) and Young Farmer Scheme (1.2%). The rest (18.8%) of the direct payments correspond to the greening payments.

[2] According to EUROPEAN COMMISSION (2017) around 80% of direct payments go to 20% of farms in EU.

velopment Payments (RDPs), as adopted by the 2013 CAP reform. Given that the EU common agricultural and trade policies are strongly interlinked and also to ensure policy coherence, the radical CAP reform analysed in this paper also considers the liberalisation of agricultural trade.

This drastic CAP Reform is highly likely not going to be adopted for the CAP beyond 2020 as suggested by the European Commission' proposal which was published in June 2018 (EUROPEAN COMMISSION, 2018a). However, it may occur in subsequent reforms as there is also criticism raised in the literature about the relevance of CAP and particularly about the legitimacy of direct payment (HEINEMANN and WEISS, 2018; MATTHEWS, 2017). In fact, England has proposed to gradually phase out direct payments from 2021 which is drafted as plan for the post-Brexit period when it will cease to be part of the EU and the CAP (DEFRA, 2018). The results of the analysis in this paper will help to better understand the economic importance of CAP for EU farms and the vulnerability and viability of the European farming sector under this drastic CAP reform. The available literature mainly focuses on analysing rather marginal changes (reforms) of CAP. The vast majority of papers analyse the CAP reform proposed or already adopted by the EU (VAN ZEIJTS et al., 2011; GOCHT et al., 2013; SOLAZZO et al., 2014; CORTIGNANI and DONO, 2015; VOSOUGH-AHMADI et al., 2015; LOUHICHI et al., 2018a). There are significantly less studies available in the literature that assess a more substantial CAP reform compared to the status-quo situation such as the elimination of the CAP (VROLIJK et al., 2010; Latruffe et al., 2013; RAGGI et al., 2013; RENWICK et al., 2013). All these studies are based either on a static behaviour, therefore not considering farmers decisions on land allocation (VROLIJK et al., 2010) or focus on farm types rather than individual farms (RENWICK et al., 2013) or specific regions based on farmers declarations of intention (LATRUFFE et al., 2013; RAGGI et al., 2013).

In this study, we use the IFM-CAP (Individual Farm Model for Common Agricultural Policy Analysis) model coupled with the CAPRI partial equilibrium model to ex-ante assess the impacts of this drastic CAP Reform. The CAPRI model makes it possible to account for the market (price and yields) effects of both trade liberalisation and CAP removal. The IFM-CAP model uses the estimated yield and price effects and an accurate representation of CAP to simulate the detailed responses of EU farmers to these shocks. In order to ensure consistency between the two models, their baselines and policy scenario were streamlined in terms of CAP implementation; the exception is the RDPs which cannot be modelled in IFM-CAP due to data limitation. As we are particularly interested in the micro-economic impacts of this drastic CAP scenario, this paper only presents the methodology and results of the IFM-CAP model.

The main advantage of IFM-CAP is that it provides a comprehensive assessment of farm-specific policies by accounting for the full heterogeneity of EU commercial farms in terms of economic behaviour and policy representation and impacts. These features of IFM-CAP allow us to analyse the extent of the economic impacts of CAP across different farm typologies and the distributional effects across farm population. These characteristics of IFM-CAP are highly relevant when assessing the impacts of CAP direct payments because the eligibility and the magnitude of direct payments are farm specific in many Member States (MS) as well as they are conditional on pursuing certain environmental farm practices (i.e. greening measures) that depend on farm production structure (LOUHICHI et al., 2017; LOUHICHI et al., 2018a; LOUHICHI et al., 2018b). Although several farm modelling approaches have been used in the literature, they cannot capture the full extent of CAP impacts at EU level, i.e. models based on representative farms are subject to significant limitations because they cannot model policies for which eligibility depends on individual farm characteristics (VAN ZEIJTS et al., 2011; GOCHT and BRITZ, 2011; GOCHT et al., 2013). Yet, available individual (real) farm-based models are usually applied only to selected Member States (MSs)/regions or to specific agricultural sectors (e.g. SOLAZZO et al., 2014; CORTIGNANI and DONO, 2015; VOSOUGH-AHMADI et al., 2015). For these reasons, most of the models used in the literature do not fully capture distributional EU-wide CAP effects across the EU farming sector.

The paper is structured as follows. The following section introduces the IFM-CAP model. The third section summarises the assumptions of scenarios that are simulated in the paper. The fourth section presents the farm income dependency of CAP payments in the baseline, followed by the results and the concluding section.

2 The IFM-CAP Model

The IFM-CAP model is a farm-level model designed for the economic and environmental analysis of the European agriculture. The main advantage of IFM-CAP is that it models a large sample of individual farms in the EU, which captures the farm heterogeneity to a degree sufficient to comprehend the impacts of the direct payments introduced by the 2013 CAP reform. The micro level detail of IFM-CAP is relevant because direct payments are farm-specific and their magnitude depends on the implementation approach applied by each MS (e.g. full *versus* partial convergence of direct payments). Further, farmers receiving direct payments need to comply with the greening measures. The greening measures are designed to incentivise good agricultural practices that contribute to environmental and climate goals. In terms of effects, they impact land use at farms level which is captured by IFM-CAP as it models land allocation within farms. More specifically, greening measures include crop diversification, maintenance of permanent grassland and ecological focus area (EFA).[3] The greening measures target land allocation at farm level implying that their adoption and impacts largely depend on farm-specific characteristics (size, specialisation, localisation, etc.). For example, the crop diversification measure, which requires farms to grow at least 2 or 3 crops, depending on farm size, can only be assessed at farm-level because aggregated models which model area allocation at regional or farm type level suffer from aggregation bias and will usually underestimate the impacts of the crop diversification measure (LOUHICHI et al., 2018a).[4] In addition, the CAP coupled payments are subject to farm specific eligibility criteria (e.g. maximum number of livestock eligible for coupled payments) which again require application of a farm level approach. This poses challenges for policy evaluation and raises the need for the application of a farm-level model. An additional advantage of IFM-CAP compared to other models used for CAP impact analysis is that it combines an EU-wide geographical coverage and the use of individual farm data that allows simulating policy impacts across all EU farming systems and regions (LOUHICHI et al., 2017; LOUHICHI et al., 2018a). However, IFM-CAP has some limitations that need to be accounted for when analysing the simulation results. These limitations particularly refer to the fact that IFM-CAP does not consider farm structural change (i.e. total farm area is assumed to be constant; there is no interaction between farms, neither farm exit/entry nor substitution between arable and grassland) and the impact of direct payments on farm-rental values is not considered because IFM-CAP does not model land markets.

IFM-CAP is a static positive mathematical programming model. The model assumes that farmers maximise their expected utility subject to resource endowments (i.e. arable and grass land and feed), and policy constraints such as CAP greening restrictions (LOUHICHI et al., 2018a). For the purpose of the present study the farmer's expected utility function is defined following the mean-variance (E-V) approach (MARKOWITZ, 2014) with a CARA (Constant Absolute Risk Aversion) specification (PRATT, 1964). According to this approach, expected utility is defined as the expected income and the associated income variance. Indeed, it is assumed that farmers select a production plan which minimises the variance of income caused by a set of stochastic variables for a given expected income level (ARRIBAS et al., 2020).

Farmer's expected income is defined as the sum of expected gross margins minus a non-linear (quadratic) activity-specific function. The gross margin is the total revenue including sales from agricultural products and direct payments (coupled and decoupled payments) minus the accounting variable costs of production activities. Total revenue is calculated using expected prices and yields assuming adaptive expectations (based on past three observations with declining

[3] Under the crop diversification, the cultivation of the arable land needs to include at least two different crops in farms cultivating between 10 and 30 hectare of the arable land and at least three crops in farms with a larger arable area. The main crop should not exceed 75% of the arable land, and the two main crops should not exceed 95% of the arable area. Under the maintenance of the permanent grassland, farms are required not to convert and to plough the permanent grassland. The EFA measure requires farms larger than 15 hectares to allocate at least 5% of farms' eligible area (excluding grassland) to the ecological focus area. The areas that qualify as an ecological focus area include the fallow land, terraces, landscape features, buffer strips, green cover, etc. (OJ, 2013).

[4] Literature shows that the effect of CAP greening on farm income is rather small at the aggregate country or EU level; however, at the disaggregated level the impacts for some farm types or some individual farms could be more pronounced (e.g. CORTIGNANI and DONO, 2015; SOLAZZO et al., 2014; SOLAZZO and PIERANGELI, 2016; LOUHICHI et al., 2018a).

weights).[5] The expected accounting costs include costs of seeds, fertilisers and soil improvers, crop protection, feeding and other specific costs (following the same approach as with expected revenues). The quadratic activity-specific function is a behavioural function introduced to calibrate the farm model to an observed base year, as usually done in positive programming models. This function intends to capture the effects of factors that are not explicitly included in the model, such as farmers' perceived costs of capital and labour, or potential model misspecifications (PARIS and HOWITT, 1998; HECKELEI, 2002; DE FRAHAN et al., 2007). Regarding the income variance, we opted for considering uncertainty in revenues, without differentiating among sources of uncertainty (ARRIBAS et al., 2020).

The general mathematical formulation of the IFM-CAP model can be written as follows (LOUHICHI et al., 2018a):

$$\text{Maximise} \quad \mathrm{E}(U) = E[p \circ y]'x - Cx + s'x + et - d'x - \frac{1}{2}x'Qx - \frac{\varphi}{2}x'\Sigma x \tag{1}$$

s.t.

$$Ax \leq b\ [\rho] \tag{2}$$

$$x \geq 0 \tag{3}$$

where $E(U)$ is the farm expected utility to be maximized, x is the $I\times1$ vector of unknown activity levels, p is the $I\times1$ vector of activity prices, y is the $I\times1$ vector of activity yields, s is the $I\times1$ vector of coupled payments, C the $I\times K$ matrix of average observed variable costs, e is the constant decoupled payment per eligible hectare, t is the constant eligible area for decoupled payments, d is the $I\times1$ vector of the linear part of the behavioural activity function, Q is the $I\times$I symmetric, positive (semi-) definite matrix of the quadratic part of the behavioural activity function, φ is the farmer's constant absolute risk aversion coefficient and Σ is the $I\times$I symmetric, positive (semi-) definite matrix of the variance-covariance activity revenues, A is the $M\times$I matrix of technical coefficients, b is the $M\times1$ vector of available resources and upper bounds to the policy constraints and ρ is the $M\times1$ vector of the dual values associated with the resource constraints.

IFM-CAP is calibrated for the base year 2012 using individual farm-level data (i.e. multiple observations) and the Highest Posterior Density (HPD) approach with prior information on NUTS2[6] supply elasticities and dual values of resources (e.g. land rental prices). The calibration to the exogenous supply elasticities is performed in a non-myopic way, i.e. we take into account the effects of changing dual values on the simulation response (for more details see LOUHICHI et al., 2018a).

The primary data source used to parameterize IFM-CAP is the individual farm-level data (83,292 farms observations for the base-year 2012) from the Farm Accountancy Data Network (FADN) database. The FADN is a European system of farm surveys that take place every year and collects structural and accountancy information on EU farms, such as farm structure and yield, output, land use, inputs, costs, subsidies, income, and financial indicators. The FADN data is unique in the sense that it is the only source of harmonized and representative farm-level microeconomic data for the whole European Union. Farms are selected to take part in the survey based on stratified sampling frames established for each EU region. The FADN survey does not, however, cover all farms in the EU, but only those which are of a size allowing them to rank as commercial farms. However, FADN represents a population of around 5 million farms, covering approximately 90% of the total utilized agricultural area and accounting for more than 90% of the total agricultural production. The aggregate FADN data are publicly available. However, farm-level FADN data, which we employ in this study, are confidential and was accessed under a special agreement for the purposes of this specific study. In order to cover the intensive data needs of IFM-CAP, the FADN data is complemented by other external EU-wide data sources such as the European Farm Structure Survey (FSS), the CAPRI model database (BRITZ and WITZKE, 2014) and Eurostat (LOUHICHI et al., 2018b). The external data sources were used in particular for the livestock module for which data needed for the base-year calibration are not available in FADN such as the nutrient content of feed, yields and prices of certain feeds (e.g. purchased feed, fodder) and nutrient requirements of animals. This

[5] Note that crop yields are fixed (exogenous) in the model version used in this paper. There is no yield response function to input quantity use (e.g. fertilisers). That is, only one intensity level (yield) is defined for each crop and individual farm, whereas costs are expressed in monetary values and are kept fixed for each crop and individual farm.

[6] NUTS2 refers to regions belonging to the second level of the Nomenclature of Territorial Units for Statistics of the European Union.

information is taken from CAPRI (NASUELLI et al., 1997; IPCC, 2006; BRITZ and WITZKE, 2014), LFL (2014), GFE (2006) and NRC (1994)), and other livestock related data (e.g. fat content of milk, selling prices of livestock) taken from Eurostat (LOUHICHI et al., 2018b).

3 Policy Scenario Assumptions

3.1 Baseline

The baseline scenario represents the current CAP development until 2030 incorporating the dynamics of the market developments from the CAPRI baseline. The CAPRI baseline is developed in conjunction with the European Commission baseline. The European Commission constructs medium-term projections for the agricultural commodity markets on an annual basis. These projections present a consistent set of market and sectoral income prospects defined on the basis of specific policy and macroeconomic assumptions (HIMICS et al., 2013; BRITZ and WITZKE, 2014).

Four assumptions were adopted to construct the IFM-CAP baseline: (i) a continuation of the current CAP up to 2030; (ii) an adjustment of baseline prices and yields (including for feed) using regional growth rates from the CAPRI baseline; (iii) an assumed inflation rate of 1.9 per cent per year (consistent with the CAPRI baseline) for input costs and (iv) an adjustment of input costs to account for improvement in farm efficiency proxied by total factor productivity (EUROPEAN COMMISSION, 2016). The regional yield growth attempts to capture both technical change and input intensification effects, and the regional price growth representing a nominal price projection. As the CAPRI growth rates of yields and prices are defined at NUTS2 level, we imposed the same growth rate on all farms belonging to the same NUTS2 region. All the other parameters (e.g. farm resource endowments and farm weighting factors) are assumed to remain unchanged up to 2030.

The IFM-CAP baseline assumes the implementation of the 2013 CAP reform. The direct payments considered in IFM-CAP are listed in Table 1. IFM-CAP baseline includes Basic Payment Scheme (BPS) considering the internal convergence and Single Area Payments Scheme (SAPS), redistributive payment, *degressivity/capping* of direct payments (i.e. reduction/maximum ceiling in the amount of direct payments that a farmer may receive, i.e. 100% cut of direct payments above a certain threshold), CAP greening, payments for Areas of Natural Constraint (ANC) and voluntary coupled support (VCS). RDPs are not modelled in IFM-CAP, hence they are implicitly assumed unchanged in baseline.[7]

The baseline also includes national direct payments: Complementary National Direct Payments (CNDP), Transitional National Aid (TNA) and National Payments (NATIONAL). Although national direct payments are not part of CAP, they are considered in the baseline because they determine farm income. The CNDP is a national aid granted to certain sectors in MS which joined the EU in 2004. With exception of Bulgaria, Croatia and Romania, since 2013, CNDP were substituted by TNA. TNA are subject to a gradual reduction. Note that these payments are not part of the CAP budget. However, the total amounts are regulated by the European Commission. Additionally, MS can grant National Payments to farmers.[8]

3.2 'NoCAP' Scenario

The NoCAP scenario aims to analyse the potential impact of a radical shift in CAP priorities related to direct payments, RDPs and trade policy. It assumes a complete removal of direct payments which primarily represents the abolition of the policy objective to support farmers' income and environmental objectives associated with CAP greening measures. However, the national payments and the Complementary National Direct Payments are kept unchanged as in baseline given that they are not part of the CAP (Table 1).

The NoCAP scenario also assumes a liberalisation of agricultural trade[9] and an abolishment of RDs. However, given that these two policy instruments cannot be implemented in IFM-CAP either because of missing data (i.e. RDPs) or because of model structure (i.e. output prices are exogenous in IFM-CAP and, thus, it cannot simulate trade policy effects), they are

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7 For more details on the modelling of direct payments and CAP greening in IFM-CAP see LOUHICHI et al. (2017), LOUHICHI et al. (2018a) and LOUHICHI et al. (2018b).

8 FADN contains information on direct payments financed from both National and EU budgets. The disentanglement between National and EU direct payments was based on the envelopes (ceilings) associated to EU funds.

9 The trade policy in CAPRI assumed to have a full tariff liberalisation for 98.5% of non-sensitive products and partial tariff reduction of 50% for the sensitive products for the Free Trade Agreements between the EU and 12 trade partners (M'BAREK et al., 2017).

primarily simulated in CAPRI (M'BAREK et al., 2017) jointly with the removal of direct payments and their combined effects are, then, transferred to IFM-CAP through yield and price changes.[10] Thus, the NoCAP scenario simulated in this paper captures the direct effect of abolishing direct payments, but also the indirect effects (through price and yield changes) of trade liberalisation and removal of RDPs. We are aware that this drastic scenario is currently to a great extent unrealistic and cannot represent a prospective or even likely development, however it might contribute to the on-going debate on the future CAP.

Table 1. Policy assumptions in the IFM-CAP baseline and NoCAP scenario

Instrument	IFM-CAP baseline - 2030	NoCAP scenario
Direct payments		
Decoupling (BPS)	BPS/SAPS	Removed
Coupled direct payment (VCS)	VCS according to the options notified by MSs up to 31/08/2015	Removed
Redistributive payment (RED)	Implemented	Removed
Young farmer scheme	Not implemented	Removed
Green payment (GREEN)	Green payment component and greening constraints implemented	Removed
Capping (CAPP)	Implemented	Removed
Areas of Natural Constraint (ANC)	Implemented (only for Denmark)	Removed
National payments		
Complementary National Direct Payments/ Transitional National Aid (CNDP)	Implemented	Kept unchanged
National payments (NATIONAL)	Kept unchanged at base year level	Kept unchanged

Source: M`Barek et al. (2017)

The CAPRI price and yield changes under NoCAP scenario are reported in Table 2. Overall, the yields tend to decrease for most product aggregates. The exceptions are the group defined as "other arable crops" as well as the beef meat activities. The decline of production caused by the yield drop leaded to an increase of crop prices with the exception of cereals. The changes in animal product prices vary by type of product depending on the changes in feed costs and production level. These price and yield changes are mostly driven by the trade liberalisation rather than removal of payments because the main bulk of the payments are decoupled from production.

Table 2. CAPRI price and yield changes in EU in NoCAP scenario (% change relative to baseline)

	Yield	Producer price
Cereals	–2.9%	–0.4%
Oilseeds	–3.5%	7.9%
Other arable crops	10.0%	3.7%
Vegs & permanent crops	–2.5%	3.4%
Dairy cows	–2.8%	11.9%
Beef meat activities	0.3%	–1.2%
Pig fattening	–3.4%	6.6%
Sheep & goat fattening	–1.7%	–1.8%
Poultry fattening	–2.7%	–1.5%

Source: M'BAREK et al. (2017)

4 Farm Income Dependency of CAP Payments in the Baseline

Table 3 and Table 4 present (expected) income[11] and direct payments by farm specialisation and economic size class in baseline in EU-27.[12] Results show that the farm income varies substantially among the different farm-types. The highest income per hectare and per farm aggregated at EU-27 level is recorded in “specialist horticulture” farms due to the production of high-value products which tend to be labour intensive. The lowest per hectare income is observed for “specialist COP” (cereals, oilseeds and protein crops) and specialist cattle, while the lowest income per farm is on “mixed livestock” and “permanent crop” farms. Regarding the farm size, as expected, larger farms

[10] CAPRI simulations also consider the imposition of GHG emissions targets as part of the EU climate action (i.e. climate policies). However, these climate policies are assumed to be the same under both baseline and the NoCAP scenario implying that they have no implications for the CAPRI price/yields changes in the NoCAP scenario (M'BAREK et al., 2017).

[11] (Expected) income refers to gross margins defined as expected revenues plus direct payments minus variable costs.

[12] Croatia is not included in the analysis due to unavailability of FADN data for the base year.

Table 3. Income and direct payments in the baseline by farm-specialisation in EU-27

Farm specialisation	Income		CAP direct payments		
	EUR/ha	EUR/farm	EUR/ha	EUR/farm	% in farm income
Mixed crops	4,270	96,239	209	4,709	4.9
Mixed crops-livestock	1,609	51,258	217	6,909	13.5
Mixed livestock	2,416	34,770	223	3,208	9.2
Permanent crops	2,666	29,651	220	2,446	8.2
Specialist cattle	919	47,231	237	12,206	25.8
Specialist COP	800	59,359	193	14,321	24.1
Specialist granivores	3,285	121,918	217	8,065	6.6
Specialist horticulture	27,400	171,719	195	12,23	0.7
Specialist milk	3,617	134,674	260	9,670	7.2
Specialist olives	1,733	19,274	357	3,966	20.6
Specialist orchards – fruits	4,346	42,676	188	1,845	4.3
Specialist other field crops	2,208	87,406	241	9,562	10.9
Specialist sheep-goats	1,246	50,391	170	6,868	13.6
Specialist wine	4,470	58,439	158	2,064	3.5
EU-27	2,081	69,787	217	7,292	10.4

Source: IFM-CAP simulation results

Table 4. Income and direct payments in the baseline by farm-economic size in EU-27

Farm size (in thousands EUR)	Income		CAP direct payments		
	EUR/ ha	EUR/farm	EUR/ ha	EUR/farm	% in farm income
2 ≤ 8 EUR	1,577	8,891	215	1,214	13.6
8 ≤ 25 EUR	1,309	2,1258	212	3,446	16.2
25 ≤ 100 EUR	1,651	75,118	215	9,760	13.0
100 ≤ 500 EUR	2,510	268,190	222	23,714	8.8
≥ 500 EUR	2,937	992,236	219	73,848	7.4
EU-27	2,081	69,787	219	7,292	10.4

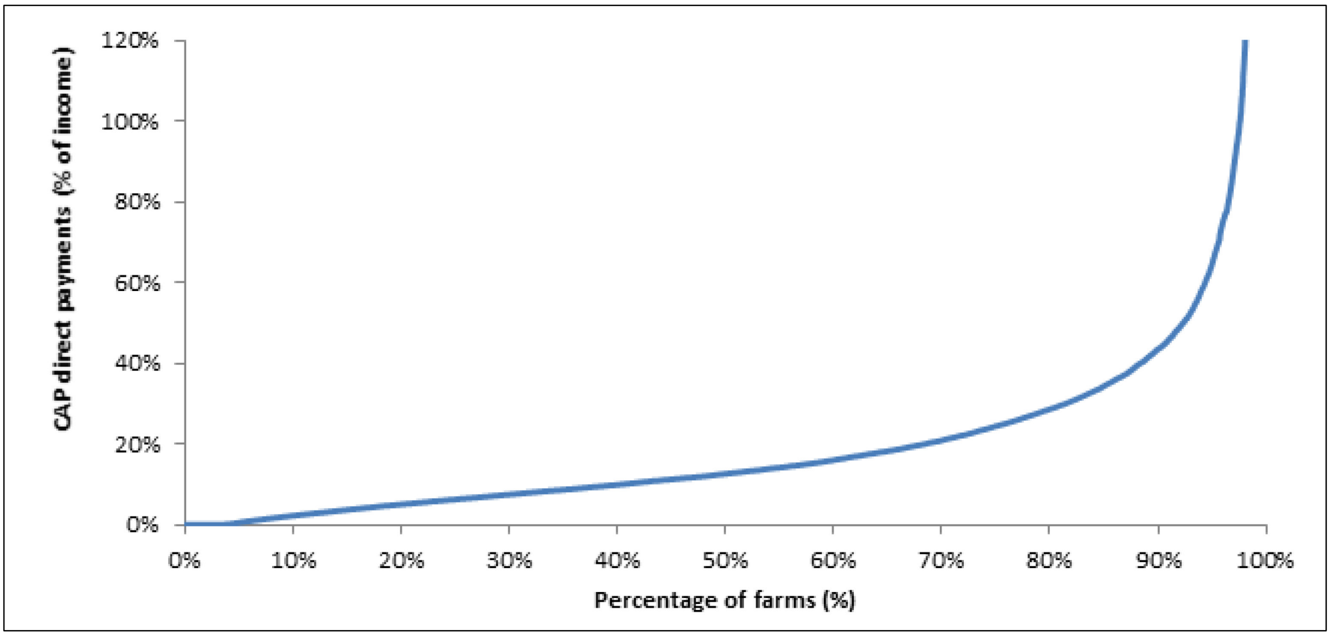
Notes: the economic size classes are presented in 1,000 EUR of Standard Output.
Source: IFM-CAP simulation result

have higher income per farm than smaller ones. Moreover, income per hectare is positively correlated with farm size because larger economic size classes tend to be involved in production of activities that are more labour and input intensive than smaller farms.

The CAP direct payments vary between 158 EUR/ha for "specialist wine" farms and 357 EUR/ha for "specialist olives" farms in EU-27. The difference of direct payments per farm is mainly due to the differences in farm structure and the eligibility criteria for subsidies. Farm specialisation receiving the lowest CAP payments per farm are "specialist horticulture" (1,223 EUR/farm), while "specialist COP" receive the highest amount, 14,321 EUR/farm. By farm size, the direct payments variation per hectare is smaller. As expected, larger farms have higher direct payments per farm than smaller ones. The biggest size class farms receive 60 times more direct payments than the smallest size farm class (Table 3; Table 4).

The most CAP subsidy dependent farms are specialised in cattle breeding, COP and olive production with the share of direct payments in income representing 26%, 24% and 21%, respectively. These farm types are expected to be most affected by the abolishment of the CAP. On the other hand, farm specialised in highly intensive sectors ("specialist horticulture" and "specialist wine"), which historically have benefit less from CAP subsidies, are less reliant on direct payments (i.e. the share of direct payments in income is below 4%). As expected, small and medium-sized farms (less than EUR 100,000 of Standard

Figure 1. Distribution of CAP direct payments as % of farm income across the farm-population in the baseline in EU-27



Source: IFM-CAP simulation results

Output)[13] are more dependent on CAP subsidies. CAP direct payments represent between 15% and 20% of the total farm income in small and medium-sized farms, while for large farms (above EUR 100,000 of Standard Output) this share is between 7% and 9% (Table 3; Table 4). At individual level, for many farms CAP subsidies account for a substantial proportion of total income: around 32% of farms receive subsidies that account for more than 20% of their total incomes (Figure 1).

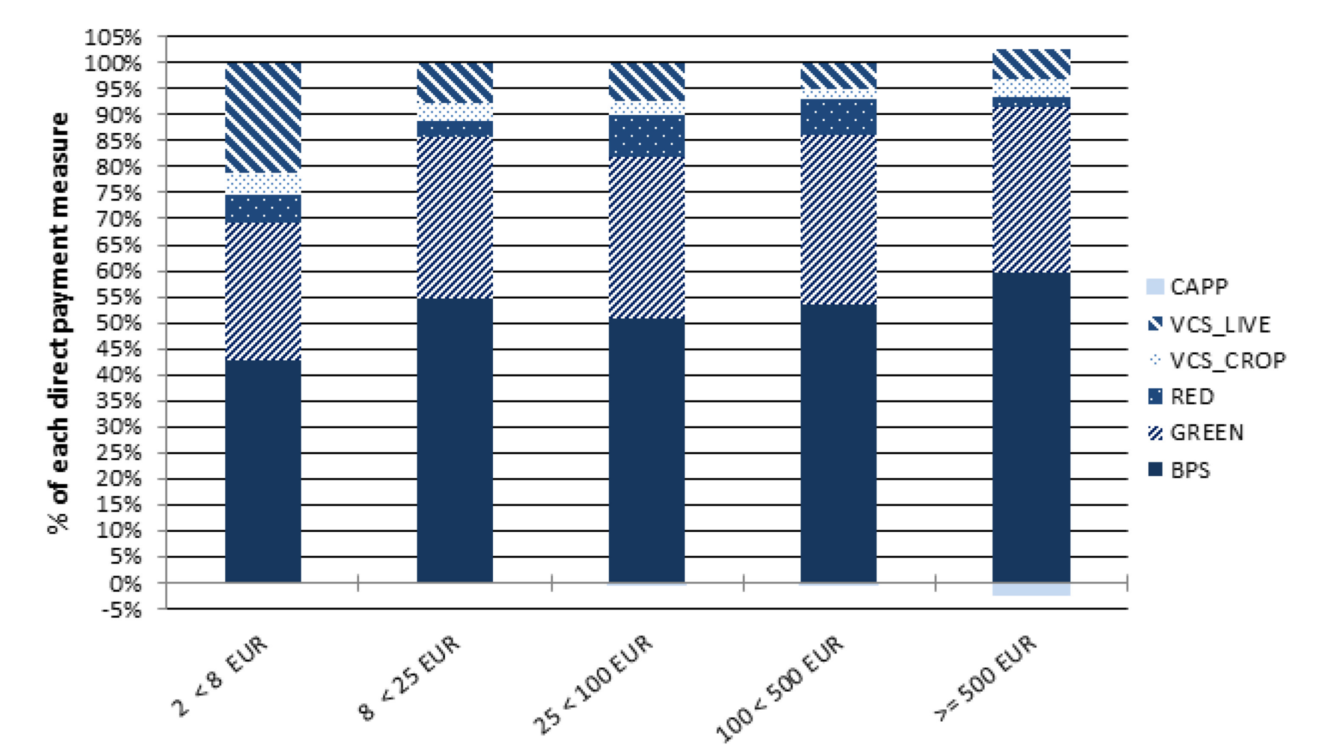
Figure 2 and Figure 3 show the composition of CAP direct payments by farm specialisation and farm size in EU-27.[14] In general, farms specialised in crop production receive higher share of decoupled payments (BPS, GREEN, RED) in total value of direct payments (more than 94.5% of total CAP direct payments compared to 86% for livestock farms). Furthermore, larger farms have a higher share of decoupled payments in total direct payments. Figure 3 shows that the capping (CAPP) affects more largest farms (-2.5 % of CAP direct payments), while it is almost negligible for the rest of the economic size classes. Capping has a negative sign because it reduces direct payments to large farms. Note that the decoupled payment (BPS, GREEN, RED) are distributed based on land use independently of the production activity carried out on land and thus they are not expected to impact land allocation decisions of farmers.

The livestock farm-types (except "specialist granivores") have a higher share of voluntary coupled support (e.g. 19.7% for "mixed livestock"; 15.3% for "specialist cattle" and 15.2% for "specialist milk"; 12.8% for "sheep and goat") compared to other farm specialisations. The strong dependency of the livestock sector on the coupled support is confirmed by the higher share of voluntary coupled support associated to livestock (VCS_LIVE) compared to crop (VCS_CROPS) sectors: 7.10% of CAP direct payments are linked to the livestock sector, while only 2.70% are allocated to the crop sector. Smaller farms tend to receive a greater share of their subsidies in the form of coupled payments. This is particularly true in the case of farms belonging to the smallest economic size class (between EUR 2,000 and EUR 8,000 of Standard Output) for which coupled payments represent around 25% of total direct payments. As a result, the farm types with higher share of coupled payments are expected to be the most affected by the removal of direct payments in terms of changes in livestock activities and land use.

13 The standard output of an agricultural product (crop or livestock) is the average monetary value of the agricultural output at farm-gate price, in euro per hectare or per head of livestock (EUROSTAT, 2018).

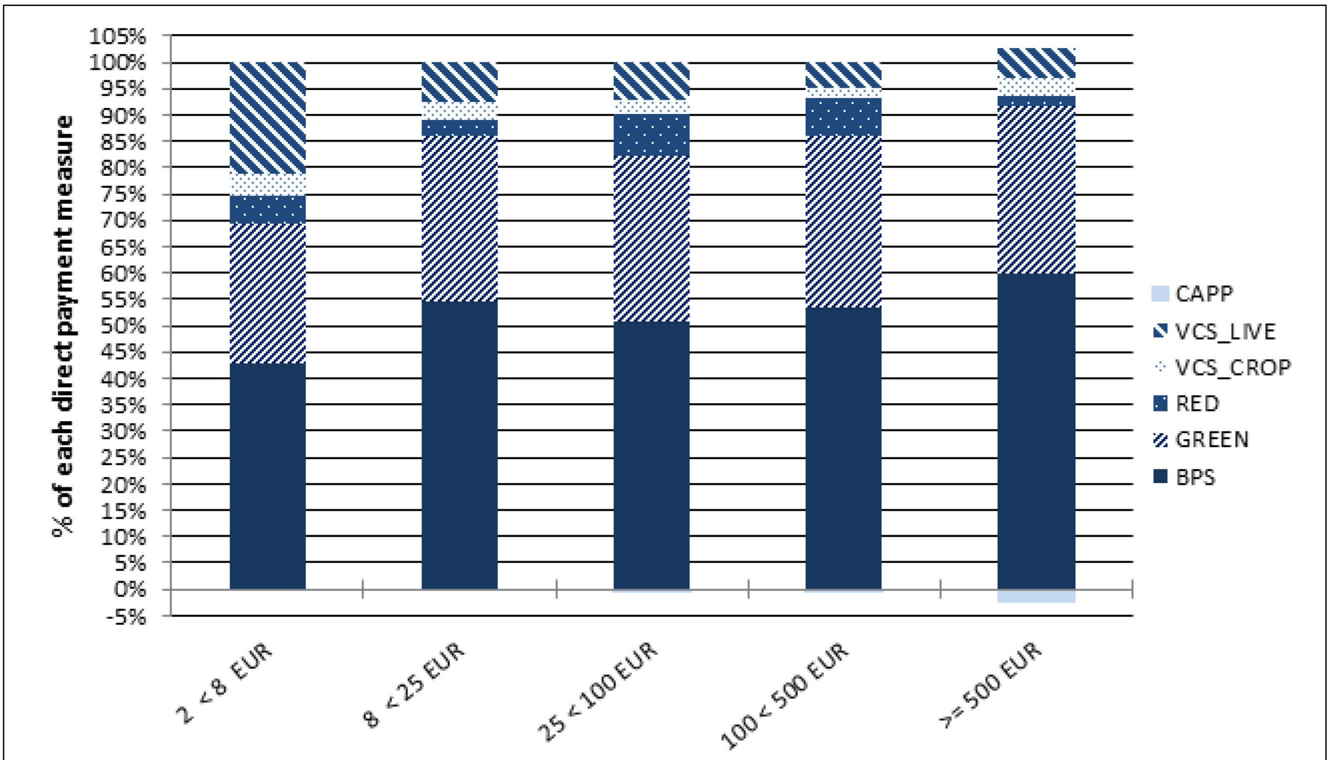
14 Areas of Natural Constraint (ANC) is not represented in Figure 2 and Figure 3 as they represent only minor share of total direct payments (less than 0.02%). Summing all the components the value is 100% (capping is considered as subsidies with a negative value).

Figure 2. The structure CAP direct payments by farm specialisation in baseline in EU-27



Notes: CAPP - Capping; VCS_LIVE - livestock coupled payments, VCS_CROP - crop coupled payments, RED- redistributive payment, GREEN – greening payment, BPS - Basic Payment Scheme/Single Area Payment Scheme.
Source: IFM-CAP simulation results

Figure 3. The structure of CAP direct payments by farm economic size in baseline in EU-27



Notes: the economic size classes are presented in 1,000 EUR of Standard Output.
CAPP - Capping; VCS_LIVE - livestock coupled payments; VCS_CROP - crop coupled payments; RED- redistributive payment; GREEN – greening payment; BPS - Basic Payment Scheme/Single Area Payment Scheme
Source: IFM-CAP simulation results

5 Results

5.1 Land Use Effects

The impact of the NoCAP scenario on land-use for different farm types is shown in Tables 5 and 6 (the results for individual activities are presented in the Appendix in Figures A1 and A2). The simulations illustrate that the NoCAP scenario leads to a substantial change in area allocation among different crops for the majority of the farm specialisations in the EU-27. In general, farms experience greater changes in minor activities in which they are not specialised (e.g. cereal and animal activities for "permanent crop" farms, vegetables and permanent crops for "field cropping" farms) than for core activities. This effect could be explained by lower adjustment costs and lower opportunity costs for minor activities than for main activities. This indirectly implies that, when CAP is removed (particularly coupled payments), farms adjust minor activities to a larger extent than core ones.

The cereal area decreases in most of the farm specialisations (on average by -2.67%) in EU-27, except in the case of "specialist sheep and goats" where we observe an increase by 11.3% relative to baseline. There is a significant increase in oilseeds area (on average by 28.7%) across all farm specialisations, except for "specialist olives", while the cultivation of vegetables and permanent crops increase by 4.62%. The increase in oilseeds, vegetables and permanent crop area is mainly caused by the increase in producer prices. Grassland is adversely affected by the removal of CAP - decreasing by 4% relative to baseline (shown in Figure A1 in appendix) - driven by the reduction in livestock activities and the abolition of permanent grassland greening measure (Table 6).

The removal of CAP leads to the reduction in cattle activities between -10% and -0.5% across farm specialisations in EU-27 which is mainly driven by the elimination of coupled payments to cattle activities and the decrease in beef prices. On the other hand, dairy cows tend to increase across most farm specialisations stimulated by higher milk producer price. On aggregate, other animal numbers are less impacted by the removal of CAP and the figures are more mixed across farm specialisations in EU-27 varying between -1.5% and 3% relative to baseline. For specific categories the impact could be more substantial. For example, the number of laying hens, which form part of the other animal category, increases by 9% relative to baseline in EU-27, while for pigs, sheep and goats there is no big differences relative to baseline (less than 1.2% in in EU-27) (Figure A2 in Appendix).

The simulated effects are less heterogeneous among economic sizes classes than among farm specialisations. However, there is a relatively consistent pattern indicating an inverse relationship between the magnitude of the simulated impacts and economic farm size. The exceptions to this are vegetables and permanent crops, where the reverse pattern is observed. The main explanation for this inverse relationship could be the greater subsidy dependence of small farms (see Table 4) and the higher proportion of coupled subsidies (see Figure 3), which leads to stronger impacts compared to large farms when CAP is eliminated. In addition, small farms are usually involved in fewer activities than large farms, which cause greater changes in relative terms when simulating policy shocks (e.g. the average number of crops is 6.2 for farms below 100 thousand EUR, while for smaller farmers is 6).

The simulation results show that the impact of NoCAP scenario on land abandonment is minimal (i.e. the land abandoned effect caused by NoCAP scenario is close to zero as a share of the total agricultural area). This result is driven by the fact that the IFM-CAP does not model land market. In IFM-CAP decoupled payments are decoupled from production with no impact on production; hence their removal does not affect profitability of land cultivation. Not modelling land market interaction between farms implies that farms do not compete for land in order to activate their BPS entitlements[15] or to be eligible for SAPS (depending on decoupled payment implementation in a given MS) (CIAIAN et al., 2018; GOCHT et al., 2013; KILIAN et al., 2012).[16] As a result, when removing CAP payments (of which decoupled payments represent the largest share), there is not a significant land abandonment effect in IFM-CAP simulations. However, the removal of CAP can have important impact on land abandonment as shown in RENWICK et al. (2013) (around 8% of total agricultural area in EU-27) who model a similar scenario as in

[15] Under the BPS, each farm is allocated a certain amount of entitlements which can be activated only if accompanied by eligible land. The impact of BPS on land use depends on the amount of allocated entitlements relative to total eligible area (for more details see CIAIAN et al., 2018; GOCHT et al., 2013; KILIAN et al., 2012).

[16] The results simulated in this paper of a minimal land abandonment effect in NoCAP scenario are consistent with the assumption of perfectly inelastic land supply. Under such assumption the removal of decoupled payments has an insignificant (or zero) effect on land use (CIAIAN et al., 2018; KILIAN et al., 2012).

our paper but use CAPRI model and assume the 2008 CAP reform ("Health Check") in the baseline.

5.2 Income Effects

Figures 4 and 5 present income changes caused by the NoCAP scenario for different farm specialisations and farm sizes in EU-27, respectively. Note that, alongside the reduction in subsidies, the income changes are driven by the prices and yields effects simulated by the CAPRI model.

Across farm specialisations in EU-27, the NoCAP scenario leads to farm income change varying between –28% to +5% compared to baseline. The income change variation is much smaller across the different economic size classes: from -12% to -1.4%. This is because sector-specific effects are diluted among different farm specialisations belonging to the same economic size class. These income changes are largely driven by the elimination of direct payments rather than price and yield changes induced by market feedback. The correlation ratio between the direct payments as a proportion of total income in the baseline scenario and the income change in the NoCAP scenarios for both farm specialisations and economic size classes is greater than 90%.

Subsidy-dependent farms experience a significant reduction in income (15% or more), such as "specialist cattle", "specialist COP" and "specialist olive farms". On the other hand, farms specialised in granivores, milk, other field-crops and horticulture production experience an increase in income because they are less dependent on subsidies while they benefit from the market effects (i.e. prices and yields changes). Small farms seem to experience greater income losses than large farms in the NoCAP scenario due to their higher subsidy dependency in the reference scenario.

Table 5. Crop area and animal number changes by farm specialisation under NoCAP scenario in EU-27 (% change compared to the baseline)

	Cereals	Oilseeds	Vegetables and permanent crops	All cattle activities	Other animals
Specialist COP	–3.63	21.24	27.37	–5.09	2.42
Specialist other field crops	–5.99	33.09	17.00	–5.40	2.22
Specialist horticulture	–13.26	10.54	8.76	–9.34	1.30
Specialist olives	–13.01	–5.56	3.04	–7.34	1.55
Specialist wine	–6.05	18.38	–0.39	–3.86	–1.21
Specialist orchards – fruits	–6.12	38.30	–2.09	–8.80	–0.79
Permanent crops combined	–6.69	13.74	0.52	–3.56	2.95
Specialist milk	–0.98	42.16	37.36	–0.52	0.25
Specialist sheep and goats	11.03	220.30	2.53	–3.47	–0.08
Specialist cattle	4.79	30.48	6.61	–4.10	–0.87
Specialist granivores	–2.72	14.30	27.47	–2.08	0.04
Mixed crops	–6.12	32.62	3.25	–5.57	0.56
Mixed livestock	–1.69	97.80	16.39	–4.45	–1.12
Mixed crops and livestock	–1.17	27.24	11.15	–3.96	0.30

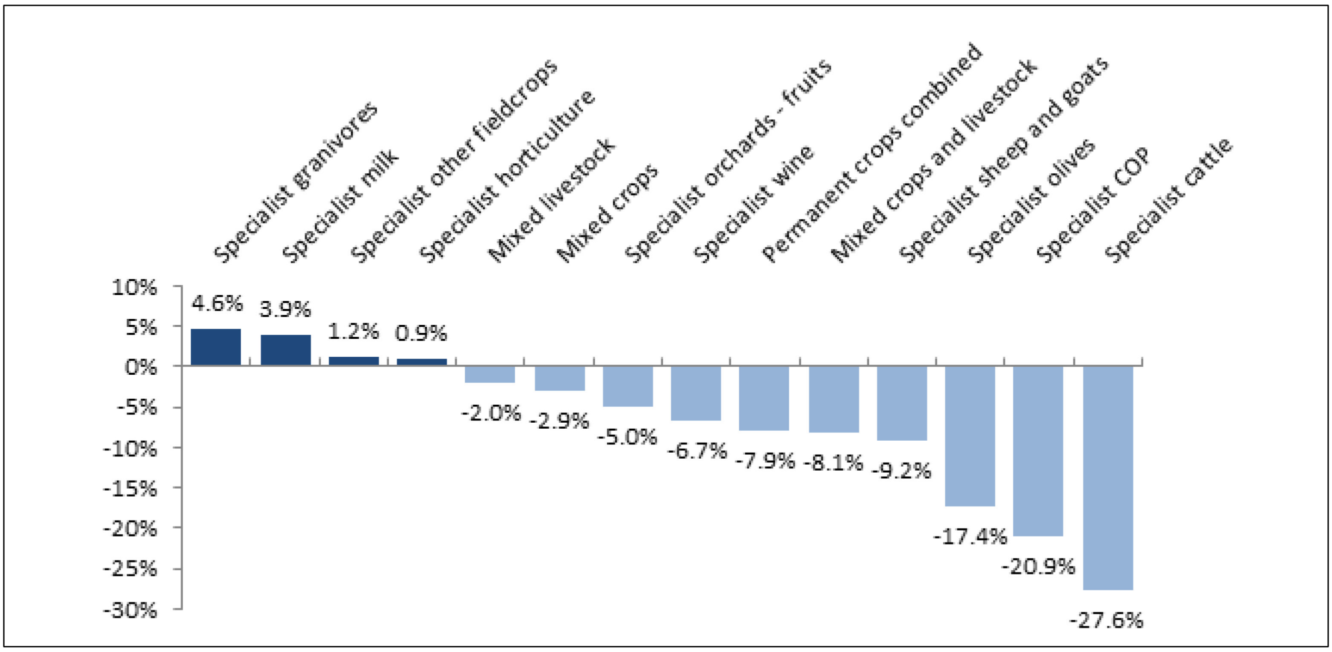
Source: IFM-CAP simulation results

Table 6. Crop area and animal numbers changes by farm size under NoCAP scenario in EU-27 (% change compared to the baseline)

Farm size (in thousands EUR)	Cereals	Oilseeds	Vegetables and permanent crops	All cattle activities	Other animals
2 ≤ 8 EUR	–7.48	199.46	0.89	–11.02	–5.19
8 ≤ 25 EUR	–0.24	55.66	2.30	–8.66	0.95
25 ≤ 100 EUR	–1.90	29.59	4.79	–3.14	0.98
100 ≤ 500 EUR	–3.90	16.12	7.91	–0.67	0.48
≥ 500 EUR	–1.42	8.94	7.10	0.06	0.55

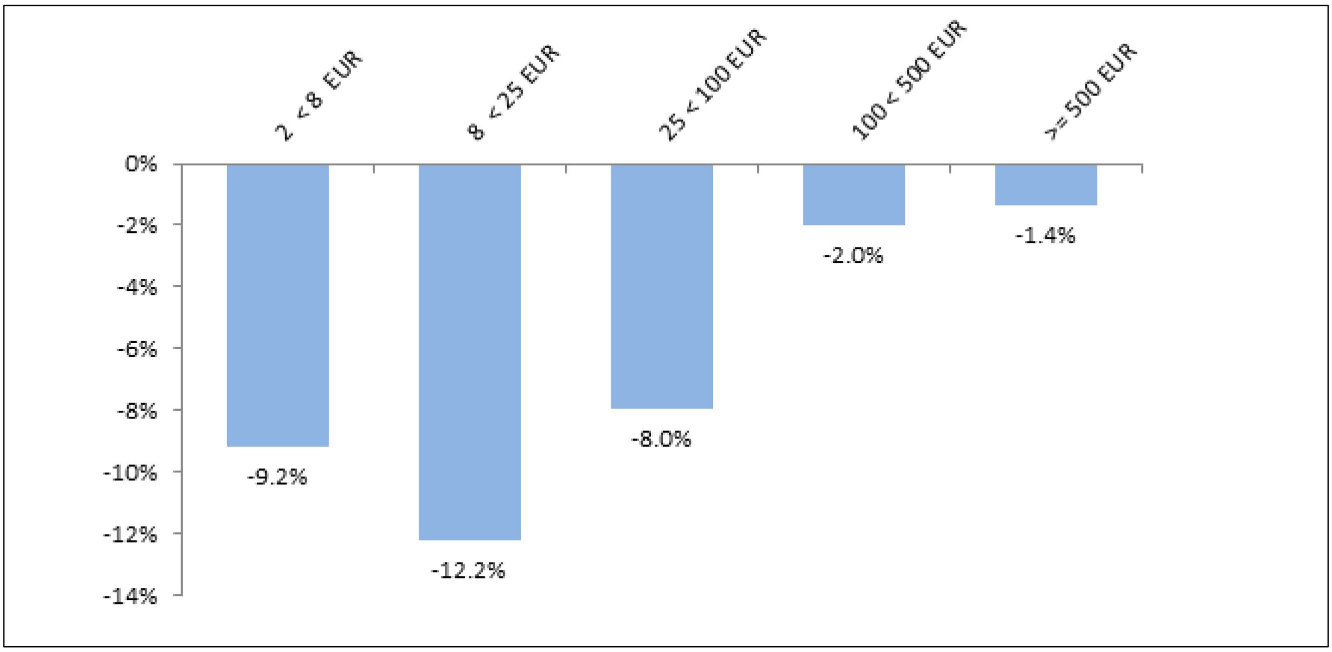
Notes: the economic size classes are presented in 1,000 EUR of Standard Output.
Source: IFM-CAP simulation results

Figure 4. Income effects of NoCAP scenario by farm specialisation in EU-27 (% change compared to baseline)



Source: IFM-CAP simulation results

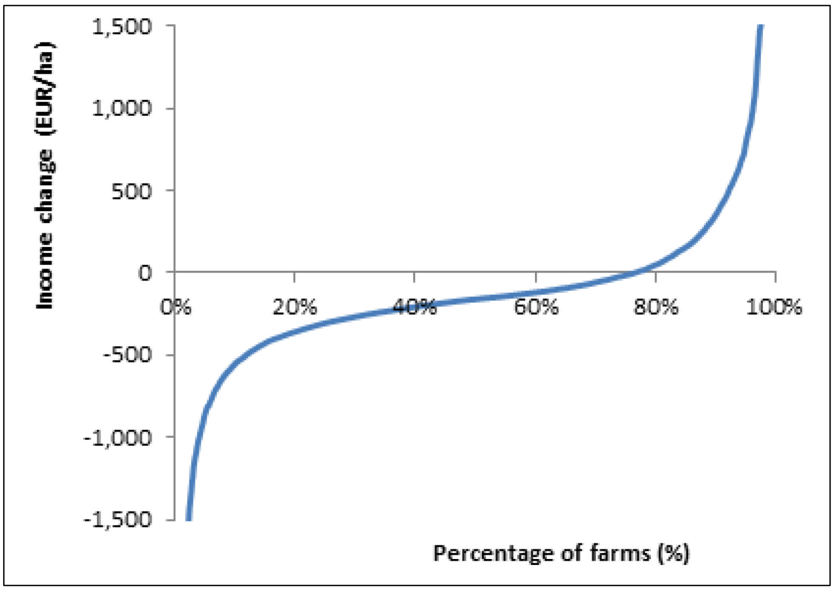
Figure 5. Income effects of NoCAP scenario by farm size in EU-27 (% change compared to baseline)



Notes: the economic size classes are presented in 1,000 EUR of Standard Output.
Source: IFM-CAP simulation results

The NoCAP scenario leads to strong impacts across farm populations in EU-27 (Figure 6). Some farms might become vulnerable in terms of attaining sufficient income to maintain farming. Further, simulation results show that most farms (around 77% of all farms) lose income in comparison to the baseline situation. Around 11.8% of all farms lose between EUR 10/ha and EUR 100/ha and 60% lose between EUR 100/ha and EUR 1,000/ha relative to baseline.

Figure 6. The distribution of farm income change per hectare caused by NoCAP scenario across the farm population in EU-27 (absolute change relative to baseline)



Source: IFM-CAP simulation results

The distributions of farm income change across Member States (MS) under NoCAP scenario are presented in Figure 7[17]. The largest average loss in income per hectare is observed in Austria, with around EUR 400/ha, and the lowest one is in Romania, with about EUR 50/ha. Only two Member States (The Netherlands[18] and Malta), which are less dependent on CAP subsides - also their agriculture are based on productions (granivores, milk and horticulture) that mostly benefit from the market effects - record an increase in the average income per hectare of approximately EUR 500/ha; however 25%[19] of their farms still lose due to the reform. The disparity in income change per hectare among farms seems to be more pronounced in the old MS than in the new ones.

By farm specialisation (Figure 8), simulation results show that more than 75% of the farms in all farm specialisation across farm populations in EU-27 lose income under the NoCAP scenario, except those specialists in horticulture[20], milk and specialist granivores. Around 90% of farms specialist COP, cattle and olives lose between EUR 10/ha and EUR 1,000/ha with an average loss of about EUR 200/ha, whereas more than 50% of farm specialized in horticulture and milk and around 30% of farm specialised in "granivores" experience an increase in income mainly driven by the market effects. The largest disparity in income change per hectare is recorded in "specialist horticulture", oscillating between ±EUR 4,000/ha, although 80% of these income changes remains within the range EUR ±1,500/ha.

By farm economic size (Figure 9) more than 80% of small farms (less than 8,000 EUR of Standard Output) experience income losses (between EUR 10/ha and EUR 800/ha) with the NoCAP scenario due to their higher subsidy dependency compared to large farms. In large farms' (more than 500,000 Euros of Standard Output) income per hectare is also adversely affected (the median is located in -180 EUR/ha), but around 30% of them seem to benefit from the NoCAP scenario because the market effects compensate the loss from subsidies.

Further, Figure 10 shows that the proportion of farms with a negative income is 2.9% of the total number of farms in the baseline scenario and this proportion increases to 4.4% of farms in the NoCAP scenario. In terms of the UAA (Utilised Agricultural Area), the share of UAA of farms with a negative income increases from 3.4% of total UAA in the baseline to 6.2% in the NoCAP scenario. These farms represent the most vulnerable group to CAP changes simulated in the NoCAP scenario because they are not able to cover the production costs. As these farms obtain negative income, they also have limited possibility to finance the renovation of capital and machinery, or to pay labour costs, thus many of them might be pressured to exit farming.[21] This implies that

[17] The bottom of each box in Figure 7 is the 25th percentile, the top is the 75th percentile and the line in the middle is the 50th percentile. The whiskers represent the lowest datum within 1.5 IQR (Interquartile Range) of the lower quartile and the highest datum within the 1.5 IQR of the upper quartile. The lines represent the mean.

[18] The result for The Netherlands is excluded from Figure 7 to keep the scale so that the others MS could be seen clearly.

[19] The exact numbers are obtained from the distribution and in the Box-Plot are not univocally identifiable.

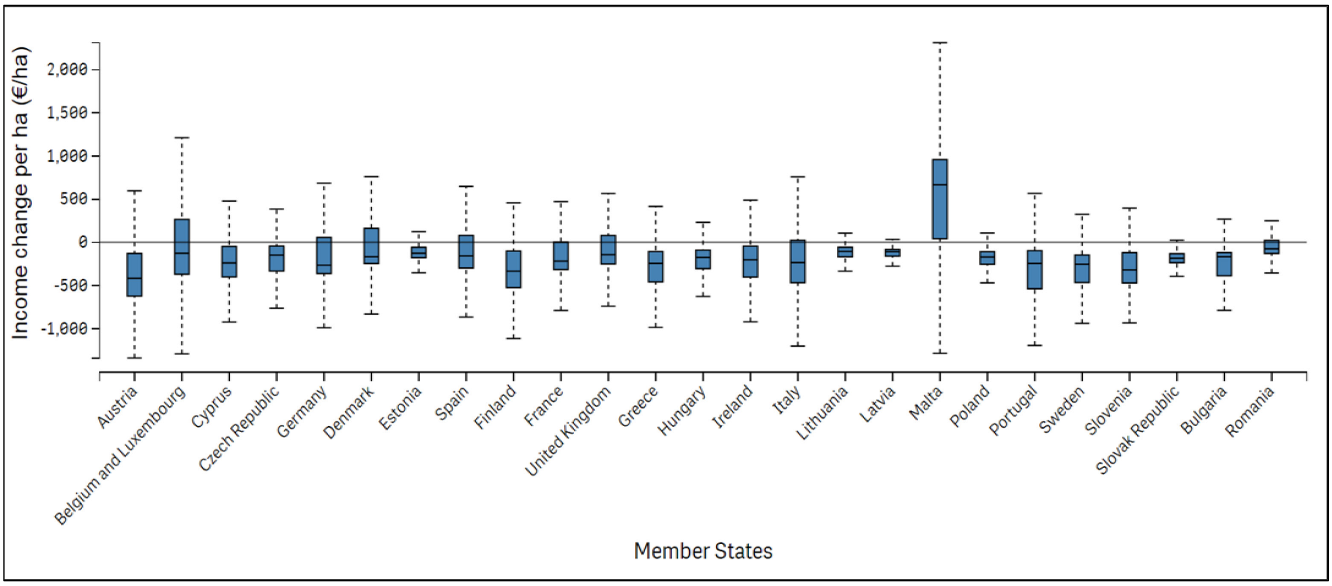
[20] The result for "specialist horticulture" is excluded from Figure 8 to keep the scale so that the others specialisations could be seen clearly.

[21] This also implies that the share of farms with negative income is greater if these costs (e.g. capital costs, labour costs) are included in the income calculation.

the farms reported in Figure 10 represent the most vulnerable farms from the economic viability point of view; and thus they represent the lower bound of the real number of farms that are at risk to exit farming.

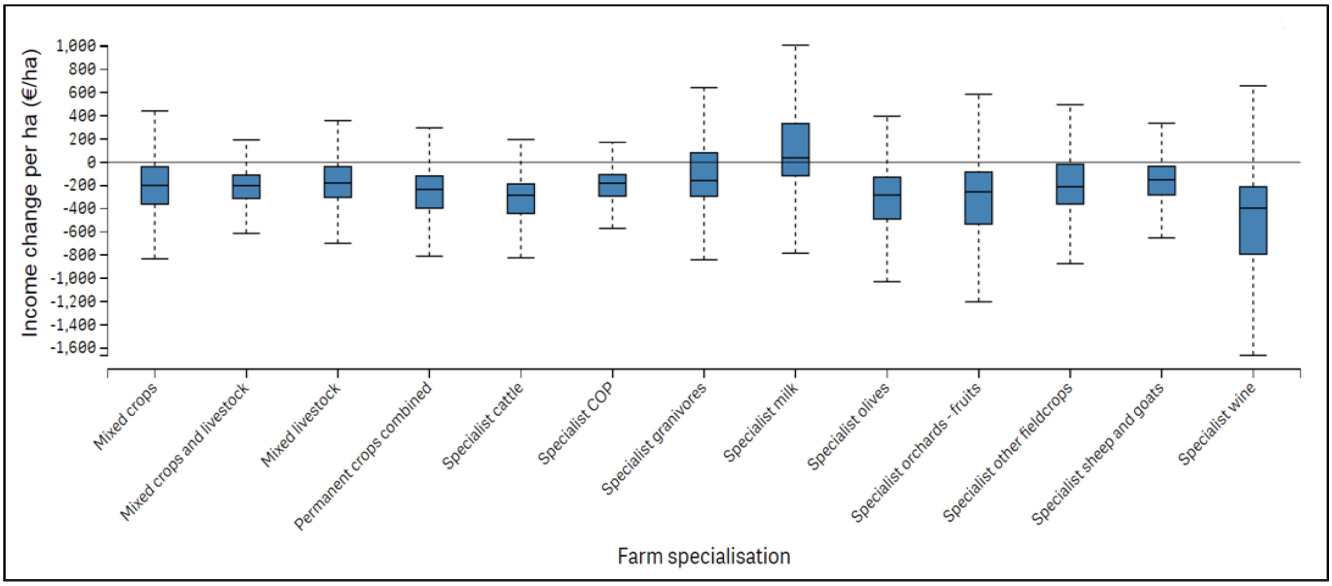
The relatively large income change under the NoCAP scenario is expected to induce structural change among EU farms. As mentioned above, the most economically vulnerable farms are those with negative income and are likely to exit farming. Farms that also experience large income decrease are potentially vulnerable and might opt to exit farming because their opportunity costs of staying in farming, determined by off-farm opportunities (e.g. employment), increases (GARRONE et al., 2019). On the other hand, farms that will continue farming might be motivated to expand farm size and/or change production specialisation in order to increase efficiency and thus sustain income viability of the farming operation. These expected effects of the NoCAP scenario cannot, unfortunately, be captured in IFM-CAP given that it does not model farm structural change.

Figure 7. The distribution of farm income change per hectare by Member State caused by the NoCAP scenario (absolute change relative to baseline)



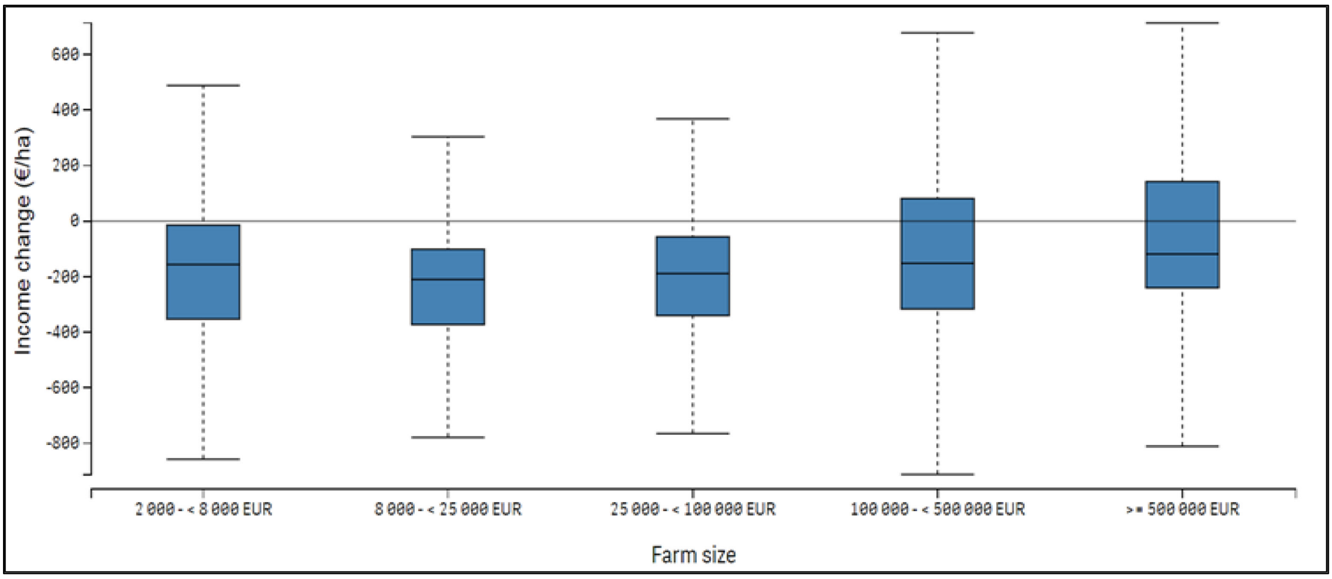
Source: IFM-CAP simulation results

Figure 8. The distribution of farm income change per hectare by farm specialisation caused by NoCAP scenario (absolute change relative to baseline)



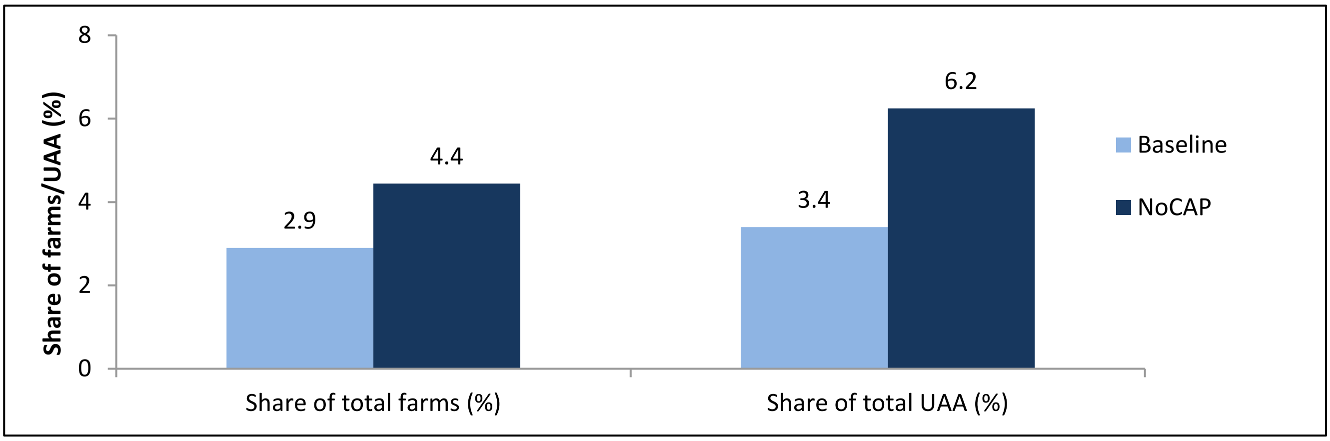
Source: IFM-CAP simulation results

Figure 9. The distribution of farm income change per hectare by farm economic size caused by NoCAP scenario (absolute change relative to baseline)



Source: IFM-CAP simulation results

Figure 10. Farms with negative income in the EU-27 (% of all farms/UAA)



Source: IFM-CAP simulation results

6 Discussion and Conclusions

This paper presents the impact of a radical CAP reform that assumes a hypothetical scenario where direct payments and RDPs are removed and trade is liberalized. We employ an EU-wide individual-farm-level model (IFM-CAP) to ex-ante assess the impacts of this scenario on EU farmers. The rationale for using IFM-CAP model is that it provides micro level analysis of the simulated policy scenario; it allows modelling farm-specific policies such as CAP direct payments (including greening) and captures farm heterogeneity across the EU in terms of policy impacts.

The simulation results show that effects of CAP removal are relatively substantial and are very heterogeneous among farms in EU. Farms that are more dependent on CAP subsides are more affected (e.g. "specialist cattle" and "specialist COP" and smallest economic size farms), while farms with higher economic output and more labour and capital intensive production are less affected (e.g. "specialist granivores"). For comparison, a similar scenario was analysed in a study by VROLIJK et al. (2010), using FADN but without using a behavioural model. In their analysis, the variable of analysis was family farm income. Compared to our income indicator, they additionally considered farming-overheads, depreciation and costs of external factors (labour, land and capital) as well as subsidies and taxes on investment. Overall, their results are similar to ours regarding the farm-types that are most (fieldcrops and grazing livestock) and least affected (granivores and horticulture). However, their analyses do not indicate that there are farm-types with increased income, while in our case there are some farm-types positively affected by CAP removal. This is explained by the fact that IFM-CAP endogenously simulates production changes considering price/yields feedbacks derived from the CAPRI market model. Further, our analyses provide land allocation effects, which are not available in VROLIJK et al., (2010). RENWICK et al. (2013) also simulated a similar scenario using CAPRI farm type model (CAPRI-FT).[22] Although both models are not directly comparable, their simulations show similar results to ours (cereal and cattle activities production tends to be adversely affected whereas other animal activities increase). In contrast, our simulations tend to show opposite effects for oilseeds and vegetables and permanent crops compared to the simulations of RENWICK et al. (2013). Further, there are also differences in CAPRI price change used in our paper compared with the ones estimated by RENWICK et al. (2013). These differences are likely driven by the differences in behavioural assumptions between the two models (individual farm level in IFM-CAP versus farm type level in CAPRI-FT), differences in CAP instruments considered in the baseline – particularly related to the greening measures, which impact crop land allocation when they are removed in IFM-CAP, versus the 2008 CAP reform considered in RENWICK et al. (2013) which does not include such measures - and differences in trade liberalisation assumptions. The simulations of RENWICK et al. (2013) also show significant land abandonment effects (around 8% of total agricultural land in EU-27) which are not captured in IFM-CAP as land market is not modelled.

The potential establishment of the radical CAP reform simulated in this paper might increase the vulnerability of some farms in terms of attaining sufficient income to maintain farming. The simulation results show that CAP plays an income stabilisation role among farms in the EU. As much as 63.8% of farms loose more than EUR 100 per hectare of income if CAP is eliminated.

Our analysis provides insights to better design policy instruments. The simulated heterogeneous income reduction and land allocative effects in our paper suggests that the main potential effects caused by the abolition of CAP could be alleviated with a more targeted approach. For example, the direct payments cuts could target less vulnerable farms with higher income levels.

One needs to be aware when drawing conclusions that our findings obviously reflect the assumptions in the model. First, we assume a fixed farm structure, implying that we do not consider farm exit and entry as a response to the policy changes. In reality, farmers may exit farming if income reduces significantly when CAP payments are removed. To account for the farm structural change, IFM-CAP needs to be further developed by the (i) adjustment of farm numbers in each farm type over the modelling horizon 2030 (i.e. in the baseline) due to farm exit and entry driven by socio-economic factors and (ii) the incorporation of behaviour responses to changes in economic incentivise (e.g. subsidies) when simulating policy scenarios (e.g. NEUENFELDT et al., 2019). A second potential caveat to our analysis is that IFM-CAP does not model land market interaction between farms implying that no land abandonment incentives are captured due to the removal of decoupled payments which could be significant as shown in RENWICK et al. (2013). Further, no land market modelling implies that we do not take into account changes in land rental prices caused by direct payments removal. The abolition of direct payments is expected to reduce the land rental prices and therefore having alleviating effects on farm income, particularly for farms that rent a substantial share of land they use.

Finally, the literature suggests that when there is a decrease in a stable source of income (such as direct payments) farmers tend to choose less risky production options in order to reduce income volatility associated with variability of prices and yields (e.g. ANDERSSON et al., 2005). These options include diversifying their production or cultivating less risky (even if less profitable) agricultural activities. Our simulation results do not confirm the increase of diversification in agricultural activities when direct payments are removed in NoCAP scenario. In fact, the average number of crops per farm decreases from 6.08 crops in baseline to 5.25 crops in NoCAP scenario. This may be explained by the fact that the elimination of direct payments implies also removal of greening measures under which crop diversification measure requires greater diversity of crop grown on the farm. The fact that famers become more risk averse with the removal of subsidies and, thus, increase diversification is not considered in IFM-CAP because we assume a Constant Absolute Risk Aversion (i.e. risk aversion coefficient is exogenous in IFM-CAP). A DARA (Decreasing Absolute Risk Aversion) model is

22 For a mode detail description of the CAPRI farm type model see GOCHT and BRITZ (2011).

more flexible and allows for considering that the initial wealth (depending partially on direct payments) determines the farmers' degree of aversion (PETSAKOS and ROZAKIS, 2015) and therefore affects land-allocation.

A careful analysis of each of these limitations to the current model is needed to test the robustness of these results and to provide a complete picture of the EU-wide impact of removing CAP. Overall, this paper provides insights by providing EU-wide analysis that is relevant to the policy debate on the efficacy of CAP in achieving its objectives.

References

ANDERSSON, H., B. BHARAT RAMASWAMI, B. CHARLES, C. MOSS, K. ERICKSON, C. HALLAHAN and R. NEHRING (2005): Off farm income and risky investment. What Happens to Farm and Nonfarm Assets? Paper prepared for presentation at the 2005 AAEA Annual Meeting, July 24-27, 2005, Providence, RI.

ARRIBAS, I., K. LOUHICHI, A. PERNI, J. VILA and S. GOMEZ-Y-PALOMA (2017): Modelling Agricultural Risk in a large scale positive mathematical programming model. In: International Journal of Computational Economics and Econometrics 10 (1): 2-32.

BRITZ, W. and H.P. WITZKE (2014): CAPRI model documentation. Institute for Food and Resource Economics. University of Bonn. In: http://www.capri-model.org/dokuwiki/..%5Cdocs%5CCAPRI_documentation.pdf.

CIAIAN, P., D. KANCS and M. ESPINOSA (2018): The Impact of the 2013 CAP Reform on the Decoupled Payments' Capitalisation into Land Values. In: Journal of Agricultural Economics 69 (2): 306-337.

CORTIGNANI, R. and G. DONO (2015): Simulation of the impact of greening measures in an agricultural area of the southern Italy. In: Land Use Policy 48: 525–533.

DEFRA (Department for Environment Food and Rural Affairs) (2018): Moving away from Direct Payments. Agricultural Bill: Analysis of the impacts of removing direct payments. In: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740669/agri-bill-evidence-slide-pack-direct-payments.pdf.

DE FRAHAN, B.H., J. BUYSSE, P. POLOMÉ, B. FERNAGUT, O. HARMIGNIE, L. LAUWERS, G. VAN HUYLENBORECK and J. VAN MEENSEL (2007): Positive Mathematical Programming for Agricultural and Environmental Policy Analysis: Review and Practice. In: Weintraub, A., C. Romero, T. Bjørndal, R. Epstein and J. Miranda (eds.): Handbook of Operations Research in Natural Resources. In: International Series in Operations Research and Management Science 99 (1): 129-154.

EUROPEAN COMMISSION (2016): Productivity in EU agriculture - slowly but steadily growing EU. Agricultural Markets Briefs No 10. In: https://ec.europa.eu/agriculture/sites/agriculture/files/markets-and-prices/market-briefs/pdf/10_en.pdf.

– (2017): Report on the distribution of direct payments to agricultural producers (financial year 2016). Ares(2017) 5942828. In: https://ec.europa.eu/agriculture/sites/agriculture/files/cap-funding/beneficiaries/direct-aid/pdf/annex2-2016_en.pdf.

– (2018a): Proposal for a regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the Common Agricultural Policy (CAP Strategic Plans). COM(2018) 392 Final. In: https://eur-lex.europa.eu/resource.html?uri=cellar:aa85fa9a-65a0-11e8-ab9c-01aa75ed71a1.0003.02/DOC_1&format=PDF.

– (2018b): A new, modern Multiannual Financial Framework for a European Union that delivers efficiently on its priorities post-2020. The European Commission's contribution to the Informal Leaders' meeting on 23 February 2018 (COM(2018) 98 final). Brussels.

EUROSTAT (2018): Standard output coefficients. European Commission. In: https://ec.europa.eu/eurostat/web/agriculture/so-coefficients.

GARRONE, M., D. EMMERS, A. OLPER and J. SWINNEN (2019). Jobs and agricultural policy: Impact of the common agricultural policy on EU agricultural employment. In: Food Policy 87: 101744.

GFE (Gesellschaft für Ernährungsphysiologie) (2006): Empfehlungen zur Energie – und Nährstoffversorgung von Schweinen. Ausschuss für Bedarfsnormen, Frankfurt/M..

GOCHT, A. and W. BRITZ (2011): EU-wide farm type supply models in CAPRI – How to consistently disaggregate sector models into farm type models. In: Journal of Policy Modeling 33 (1): 146-167.

GOCHT, A., W. BRITZ, P. CIAIAN and S. GOMEZ Y PALOMA (2013). Farm Type Effects of an EU-wide Direct Payment Harmonisation. In: Journal of Agricultural Economics 64 (1): 1-32.

HECKELEI, T. (2002): Calibration and Estimation of Programming Models for Agricultural Supply Analysis. Habilitationsschrift an der Landwirtschaftlichen Fakultät der Rheinischen Friedrich-Wilhelms-Universität, Bonn.

HEINEMANN, F. and S. WEISS (2018): CAP Beyond 2020: Seven More Years of Money for Nothing? EconPol Europe Opinion 11, October 2018. In: http://www.econpol.eu/opinion_11.

HIMICS, M., P. CIAIAN, B. VAN DOORSLAER and G. SALPULTRA (2012): Management Guideline for the CAPRI Baseline. Deliverable D4.8, FP7 project "Common agricultural policy regional impact – the rural development dimension (CAPRI-RD). In: http://www.uni-bonn.de/agpo/rsrch/capri-rd/docs/d4.8pdf .

IPCC (Intergovernmental Panel on Climate Change) (2006): IPCC Guidelines on National Greenhouse Gas Emission Inventories. Hayama, Japan.

KILIAN, S., J. ANTON, K. SALHOFER and N. RODER (2012): Impacts of 2003 CAP Reform on Land Rental Prices and Capitalization. In: Land Use Policy 29 (4): 789-797.

KIRYLUK-DRYJSKA, E. and A. BAER-NAWROCKA (2019): Reforms of the Common Agricultural Policy of the EU: Expected results and their social acceptance. In: Journal of Policy Modeling 41 (4): 607-622.

KLAIBER, A.L., K. SALHOFER and S.R. THOMPSON (2017): Capitalisation of the SPS into Agricultural Land Rental Prices under Harmonisation of Payments. In: Journal of Agricultural Economics 68 (3): 710-726.

LATRUFFE, L., A. DUPUY and Y. DESJEUX (2013): What would farmers' strategies be in a no-CAP situation? An illustration from two regions in France. In: Journal of Rural Studies 32: 10-25.

LfL (Bayerische Landesanstalt für Landwirtschaft) (2014): Gruber Tabelle zur Fütterung in der Rindermast. In: http://www.lfl.bayern.de/mam/cms07/publikationen/daten/informationen/p_31941.pdf.

Louhichi, K., P. Ciaian, M. Espinosa-Goded, A. Perni, L. Colen and S. Gomez y Paloma (2017): Does the Crop Diversification Measure impact EU farmers' decisions? An assessment using an Individual Farm Model for CAP Analysis (IFM-CAP). In: Land Use Policy 66: 250-264.

Louhichi, K., P. Ciaian, M. Espinosa, A. Perni and S. Gomez y Paloma (2018a): Economic impacts of CAP greening: application of an EU-wide individual farm model for CAP analysis (IFM-CAP). In: European Review of Agricultural Economics 45 (2): 205–238.

Louhichi, K., M. Espinosa, P. Ciaian, B. Vosough Ahmadi, A. Perni, L. Colen and S. Gomez y Paloma (2018b): The EU-Wide Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP v.1): Economic impacts of CAP greening. EUR 28829 EN. European Commission, Joint Research Centre, Publications Office of the European Union, Luxembourg.

Matthews, A. (2017): Why Further Reform? Appendix 1. In: Buckwell, A., A. Matthews, D. Baldock and E. Mathijs: CAP – Thinking Out of the Box: Further modernisation of the CAP – why, what and how? RISE Foundation, Brussels: 29-30.

Markowitz, H. (2014): Mean-variance approximations to expected utility. In: European Journal of Operational Research 234 (2): 346-355.

M'barek, R., J. Barreiro-Hurle, P. Boulanger, A. Caivano, P. Ciaian, H. Dudu, M. Espinosa Goded, T. Fellmann, E. Ferrari, S. Gomez y Paloma, C. Gorrin Gonzalez, M. Himics, K. Louhichi, A. Perni Llorente, G. Philippidis, G. Salputra, P. Witzke and G. Genovese (2017): Scenar 2030 - Pathways for the European agriculture and food sector beyond 2020. No JRC108449, JRC Working Papers, Joint Research Centre, Seville.

Michalek, J., P. Ciaian and D. Kancs (2014): Capitalization of the Single Payment Scheme into Land Value: Generalized Propensity Score Evidence from the European Union. In: Land Economics 90 (2): 260-289.

Nasuelli, N., G. Palladino, M. Setti, C. Zanasi and G. Zucchi (1997): FEED MODULE: requirement functions and restriction factors. CAPRI Working Paper 97-12. In: http://www.ilr.uni-bonn.de/agpo/publ/workpap/pap97-12.pdf.

Neuenfeldt, S., A. Gocht, T. Heckelei and P. Ciaian (2019): Explaining farm structural change in the European agriculture: A novel analytical framework. In: European Review of Agricultural Economics 46 (5): 713-768.

NRC (National Academy Press) (1994): Nutrient Requirements of Poultry: Ninth Revised Edition. Subcommittee on Poultry Nutrition, Committee on Animal Nutrition, National Research Council, National Academy Press, Washington, D.C.

OJ (Official Journal of the European Union) (17.12.2013): No. L 347/608 (2013). In: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1307&from=EN.

O'Neill, S. and K. Hanrahan (2016): The capitalization of coupled and decoupled CAP payments into land rental rates. In: Agricultural Economics 47 (3): 285-294.

Paris, Q. and R.E. Howitt (1998): An Analysis of Ill-posed Production Problems Using Maximum Entropy. In: American Journal of Agricultural Economics 80 (1): 124-138.

Petsakos, T. and S. Rosakis (2015): Calibration of agricultural risk programming models. In: Journal of Operational Research 242 (2): 536-545.

Pratt, J.W. (1964): Risk Aversion in the Small and in the Large. In: Econometrica 32 (1-2): 122-136.

Raggi, M., L. Sardonini and D. Viaggi (2013): The effects of the Common Agricultural Policy on exit strategies and land re-allocation. In: Land Use Policy 31 (1): 114-125.

Renwick, A., T. Jansson, P.H. Verburg, C. Revoredo-Giha, W. Brit, A. Gocht and D. McCrackena (2013): Policy reform and agricultural land abandonment in the EU. In: Land Use Policy 30 (1): 446–457.

Solazzo, R., M. Donati, F. Arfini and G. Petriccione (2014): A PMP model for the impact assessment of the Common Agricultural Policy reform 2014-2020 on the Italian tomato sector. In: New Medit 2 (13): 9-19.

Solazzo, R. and F. Pierangeli (2016): How does greening affect farm behaviour? Trade-off between commitments and sanctions in the Northern Italy. In: Agricultural Systems 149: 88-98.

Van Herck, K., J. Swinnen and L. Vranken (2013): Capitalization of Direct Payments in Land Rents: Evidence from New EU Member States. In: Eurasian Geography and Economics 54 (4): 423-443.

Van Zeijts, H., K. Overmars, W. van der Bilt, N. Schulp, J. Notenboom, H. Westhoek, J. Helming, I. Terluin and S. Janssen (2011): Greening the Common Agricultural Policy: impacts on farmland biodiversity on an EU scale. Policy Report No. 500136005. PBL Netherlands Environmental Assessment Agency, The Hague.

Vosough-Ahmadi, B., S. Shrestha, S.G. Thomson, A.P. Barnes and A.W. Stott (2015): Impacts of greening measures and flat rate regional payments of the Common Agricultural Policy on Scottish beef and sheep farms. In: Journal of Agricultural Science 153 (4): 676-688.

Vrolijk, H., C. De Bont, P. Blokland and R. Soboh (2010): Farm viability in the European Union: Assessment of the impact of changes in farm payments. LEI report 2010-011. In: http://edepot.wur.nl/138917.

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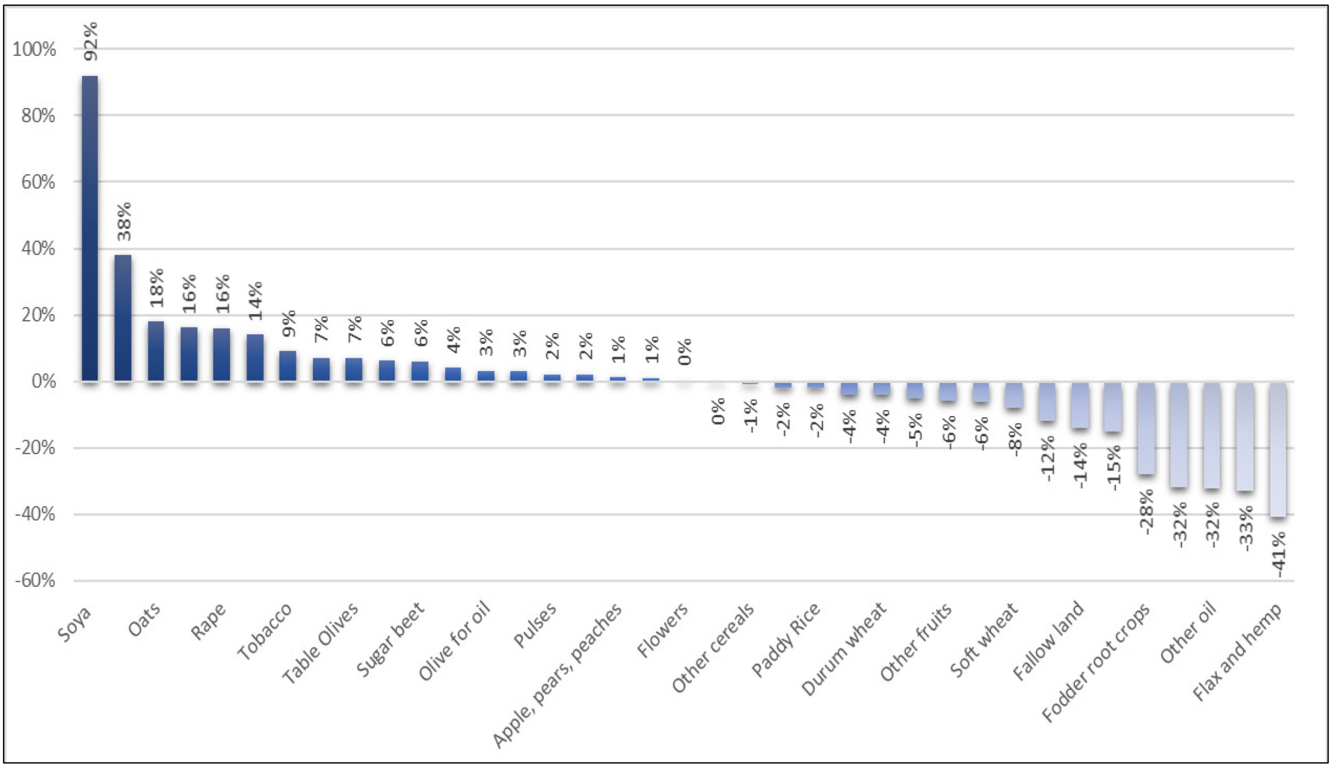
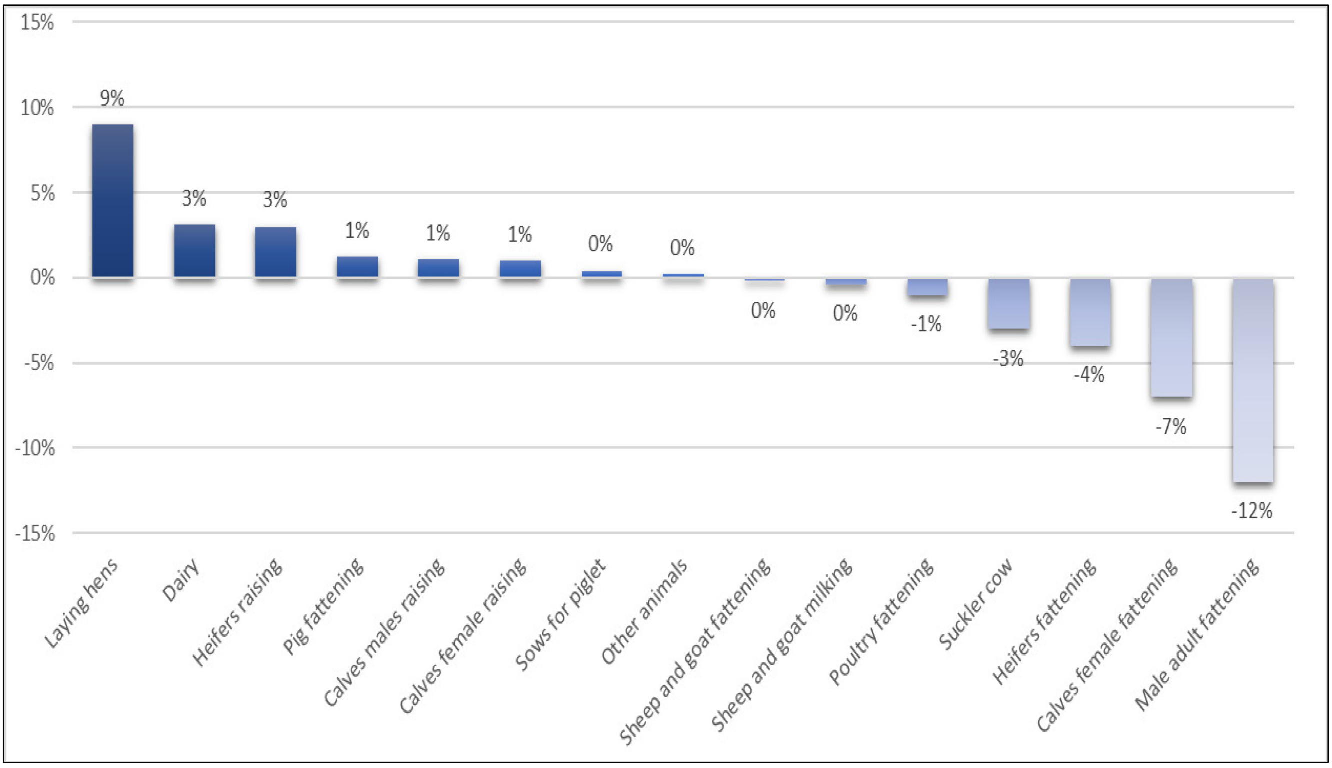
Appendix

Figure A1. Crop area changes under NoCAP scenario in EU-27 (% change compared to the baseline)



Source: IFM-CAP simulation results

Figure A2. Animal numbers changes by category under NoCAP scenario in EU-27 (% change compared to the baseline)



Source: IFM-CAP simulation results