Did green payments' crop diversity criterion induce change in economic, environmental and land use condition in France?

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September 14, 2022

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Abstract

How modern agriculture should be more environmental sensitive? This question has raised extensive debate among scholars. Reducing the negative agricultural footprint on the environment has been vital for policy-makers. The European Union (EU), by means of the 2013 reform of the Common Agricultural Policy (CAP), have introduced a new component called green payment with the objective to improve environmental performance of European farms. Fierce debates have taken place among scholars about its effects on the environment. This study intends to bring some clarity to the matter by analysing the effect of green payments' crop diversity criterion on farms' economic, environmental and land use conditions. Using a difference in discontinuity design with French FADN data, the results show significant negative significant effect on economic condition. Our study goes a step further by showing that potential better environmental and land use results and no detrimental income effect could have been obtained with better targeting.

Keywords : Green Payments, Crop Diversification, Difference in discontinuity, Windfall Effect, France.

JEL Codes : **Q12, Q15, Q18, Q57, C31.**

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1 Introduction

The European Union (EU), through the Common Agricultural Policy (CAP), have aimed to preserve the productive capacity of agriculture but also, more recently, safety and quality of food and its environmental impacts (European Commission, 2010). Indeed, the latter objective is a fundamental for policymakers and consumers. Therefore, many reforms have been made to better account for the environmental dimension of the agricultural production. The reform adopted in 2013 intended to match this target by introducing the so-called greening component. Its objective is to improve environmental performance of farms (European Union, 2013). The main idea is to reward farmers for provision of environmental services that are not paid for by the market (European Commission, 2010; European Economic and Social Committee, 2012; European Union, 2013). Farmers receiving green payment should respect 'simple, generalised, non-contractual and annual actions that go beyond cross-compliance and that are linked to agriculture, such as crop diversification, the maintenance of permanent grassland, including traditional orchards where fruit trees are grown in low density on grassland, and the establishment of ecological focus areas' (European Union, 2013, Article 37). Therefore, the practices that are beneficial for the environment and the climate are privileged.

Is this reform enough to bring desired environmental changes? Will it be able to achieve synergy between the economic and environmental aspect? The objective of this study is to bring light to these questions. We aim to evaluate the economic, environmental and land-use consequences of the 2013 CAP reform on French farms. More precisely, our research studies the economic, environmental and land use consequences of green payment crop diversity criterion on farms. These questions are very important not only for policymakers in the EU but also for all actors of the agriculture value chain such as farms and consumers.

The 2013 CAP reform has led to a surging literature that wishes to analyse its effects. Many papers have studied the reform consequences in the environmental aspect, but also in the economic and land-use dimension. For instance, Cortignani et al. (2017) showed a fall in the Shannon index in Italy, accompanied by a reduction of the main crop share. This positive effect on the environment is confirmed by other studies. Indeed, Solazzo et al. (2016) evaluated the potential reduction of greenhouse gases (GHG) following the CAP reform. They showed a reduction of 1.5% of the GHG in Italy. Nevertheless, this reduction is considered to be small compared to the initial proposal of the Commission. Their results also highlighted a low impact in terms of land use, with a reduction of acreage only for maize. This result is confirmed at the EU level by the study of Gocht et al. (2017). They also found a reduction of 2% of GHG but also an increase of ammonia emissions and no significant effect on nitrogen surplus in Europe. This latter result shows a contrasting effect of the reform on the environment.

There is also debate on the economic impact of the reform. Cortignani et al. (2017) found a reduction of the gross margins in Italy due to the convergence criteria, but also a negative effect on income imputable to coupled payment introduced. A similar effect is also found by Louhichi et al. (2017, 2018) at the European and Member States (MS) level. However, the results of Gocht et al. (2017) highlighted a positive effect on the income in the EU. This result is mainly due to price effect after the reform.

Our paper differs from the existing literature in four aspects. First, this is the first paper, to the best of our knowledge, to analyse the crop diversity criterion effect on technical efficiency (TE) and environmental efficiency (EE) of farms. Analysing its effects on both TE and EE is crucial. Indeed, one of the main objective of the CAP since its inception is to improve agricultural productivity but also the efficient use of factors of production (Massot, 2016). TE is recognised as a indicator of competitiveness but also of productivity and efficiency as it allows measuring the maximum level of production attainable with the minimum level of inputs (Latruffe, 2010). The reform effect on EE is also insightful, as one of the main objective of green payments is to enhance environmental performance (European Court of Auditors, 2017; European Union, 2013). Studying the effect of the crop diversity criterion on both TE and EE is also crucial, as it brings clarity to the dual objective of recent reforms of CAP: promoting agricultural productivity while enhancing environmental performances of farms. Second, this is also the first attempt to evaluate causal effect of the reform with impact evaluation techniques. Most of the existing literature use simulation based on mathematical programming (Solazzo et al., 2016; Solazzo and Pierangeli, 2016; Gocht et al., 2017; Cortignani et al., 2017; Louhichi et al., 2017, 2018), Markov chain model (Bertoni et al., 2018, 2021) or panel data model (Olagunju et al., 2022). We aim to exploit the natural experimental setting of the reform. Third, it is the first study to offer a broad view of the reform effect on three dimensions (economic, environmental, land use). Some other papers have studied only one ((Solazzo et al., 2016; Bertoni et al., 2021)) or two of these dimensions (Solazzo et al., 2016; Gocht et al., 2017; Louhichi et al., 2017, 2018; Cortignani et al., 2017). Fourth, this is also the first study, to the best of our knowledge, analysing the effect of green payment crop diversity criterion on French farmers.

The rest of this paper is organised as follows. Section 2 presents the core of the 2013 CAP reform and the literature review. The methodology is described in section 3 followed by the description of the data used in the section 4. The section 5 discusses the results of our analysis and section 7 concludes.

2 Background and Literature Review

2.1 CAP Green Payments

There has been rising concerns about the environmental impact of agricultural practices from the European taxpayers and consumers (European Economic and Social Committee, 2012; Erjavec and Erjavec, 2015). Indeed, fierce societal criticism has emerged on the CAP concerning environment and food (Erjavec and Erjavec, 2015). Public interventions have been aiming to address these concerns with CAP reforms. The 2013 CAP Reform intended to bring a clear switch in the objectives of European agricultural policies (Louhichi et al., 2018). One of the main stated objectives of the new CAP 2014-2020 was to improve the environmental performances of farms by introducing a 'greening' component (European Union, 2013). Greening payments are part of direct payments from the CAP first pillar. They aim to support provisions of environmental benefit from agricultural practices (European Union, 2013). European Economic and Social Committee (2012) justifies these supports as market returns compensation for provision of environmental services. Therefore, there is a clear inclusion of positive externalities generated on farms (European Court of Auditors, 2017).

The objective is to retribute[1] farms that meet three criteria beneficial for the environment: i) crop diversification, ii) ecological focus areas and iii) maintenance of permanent grassland (European Union, 2013).

The crop diversification criterion implies to increase the number of crops on farm. If farm's arable land is lower than 10ha, the farm is not subjected to the crop diversity criterion. If farm arable land ranges between 10 ha and 30 ha, it should have at least two crops in the diversification and the main crop share of the arable land should not represent more than 75% (Louhichi et al., 2017; European Court of Auditors, 2017). If the arable land is higher than 30 ha, farms should have at least three crops. Moreover, the share of the main crop share should not exceed 75% and the two main crop share should not be higher than 95% (European Court of Auditors, 2017).

Some exemptions have been made, especially farms applying environmental beneficial activities such as organic farms (European Union, 2013; Massot, 2016). Farms with less than 10 ha of arable land are not subjected to crop diversification component (Louhichi et al., 2018). Farms with grassland covering more than 75% of the total eligible land or farms with forage representing 75% of cultivated arable area are also exempted (Louhichi et al., 2018). The environmental benefit sought here is the improvement of soil quality (European Economic and Social Committee, 2012). Indeed, intercrops (cultivating two or more crops) may increase the biological nitrogen fixation (legumes for instance) and therefore improve the soil fertility. Moreover, it can ameliorate soil conservation and canopy structure (Lithourgidis et al., 2011).

The ecological focus area (EFA) component exacts farms with arable land higher than 15 ha to dedicate no less than 5% of it to EFA (European Union, 2013; European Court of Auditors, 2017; Cortignani et al., 2017). This measure aims to improve biodiversity (European Union, 2013) and therefore targets areas directly related to it, such as buffer strips, fallow land, nitrogen-fixing crops, etc (Cortignani et al., 2017; European Union, 2013).

The maintenance of permanent grassland entails that the ratio of grassland/total agricultural area should not be any lower of 5% than the reference ratio (before greening)[2] (Eu-

[1] The retribution concerns 30% of the direct payment (Louhichi et al., 2018).

[2] European Union (2013) highlights that Members States (MS) should choose at which territorial level to

ropean Union, 2013). If the ratio is worsened by 5%, the grassland conversion will be completely forbidden. In France, a derogatory ratio of 2.5% is made as a warning signal (MAAF, 2021), meaning that when the ratio is worsened by 2.5%, an administrative authorisation should be issued to allow further conversions (MAAF, 2021).

The reform came into forced in 2014 (European Union, 2013). Therefore, the first payments have been received in 2015 following entitlements of 2014. Figure 1 shows the average green payments and the 1st pillar subsidies by year in France. There is a decreasing tendency of the 1st pillar subsidies starting from 2013.

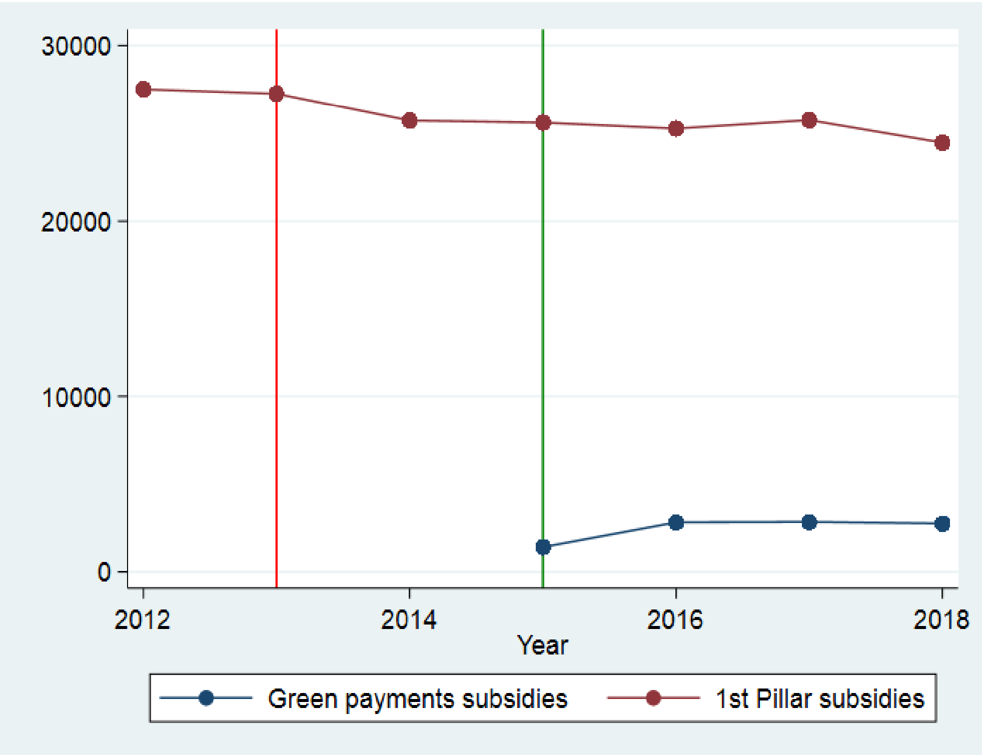

Figure 1: Yearly average greening and 1st pillar subsidies in Euros for France. Source: authors' own elaboration.

The green payments increase steadily between 2015 and 2016 and seems constant for the rest of the year. 2014 was the transitional year, and farms start to receive payments in 2015. The next section presents country-specific or EU-wide studies on the potential effects of greening, but also studies of crop diversity effect on productivity and production.

apply the ratio. In France, the ratio is applied at the regional level (MAAF, 2021).

2.2 Literature Review

There is a growing literature analysing the effects of the 2013 CAP reform on land use, production of farms and their income, but also the environmental consequences of this reform. Scholars have been interested in the consequences of greening payment or more generally 2013 CAP reform, in the area allocation of crops on the farm.

For instance, Cortignani et al. (2017) evaluate potential consequences of the greening, but also the overall reform of the first pillar on land use, environmental indicators, and economic results in three regions of Italy (Lombardia, Marche and Puglia). The methodology relies on Positive Mathematical Programming (PMP) model with two scenarios envisaged : i) the entire reform is considered and ii) only greening is taken into account. Using Farm Accountancy Data Network (FADN) for the 2013 period, their results suggest that the whole reform of the CAP has changed farms' land use aspect. The area dedicated to the main crop decreased both in all three regions. This is mainly due to a substitution made by farmers. They introduce new crops in order to fulfil the greening obligation by reducing the main crop area. However, this effect is mainly driven by the coupled payment and less by the greening scheme of the reform. When the greening scenario is only considered, the main crop area reduction is much lower (1/3 of the total reduction). The effect of the greening, per se, is either lower than the entire reform or in contradiction to the effect of the reform. Similar patterns were observed by Louhichi et al. (2018) who study the farm-level impacts of greening measure using Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP), an EU-wide individual farm-level model. The IFM-CAP is applied with 3 scenarios: i) same support as the greening criterion till 2025; ii) inflation rate of 1,9 for input costs and; iii) adjustment of baseline prices and yields with growth rates. Their results highlighted a relocation of land in EU-27 due to greening measures, where 4.5% of the total area is relocated. This effect is mainly driven by the Ecological Focus Area (EFA) criterion (2.4%) while crop diversification and grassland criteria play a secondary role (respectively 1.8% and 1.5%). However, heterogeneous effect is observed within Member States (MS) (greening measures being more or less important for different countries for area relocation).

The 2013 CAP reform not only affects the land use and area allocation, but also the land prices. Olagunju et al. (2022) investigate the effect of the 2013 CAP reform on land rental value under in Northern Ireland. Using a Dynamic panel model, they found that the 2013 CAP reform increase the long-term capitalisation from 15 pence to 30 pence. The capitalisation increase in 2015 can be explained by a temporary behaviour changes in which some landowners reduce the land rented in order to take advantage of entitlement reallocation opportunities and receive the payment.

The 2013 CAP reform environmental effects have also been highlighted. Gocht et al. (2017) analyse the potential economic and environmental impacts of CAP greening. The research is based on simulations with CAPRI models based on five scenarios: i) no greening reform; ii) greening; iii) crop diversification only applied; iv) EFA only applied and v) Permanent grassland only applied. Using data from FSS in 2007 and FADN for the 2007–2009 period at NUT-2 levels for EU-28, EU-15 and EU-13, their results show a reduction of GHG emissions of 0.2%, a positive effect on ammonia emissions, but no significant effect on nitrogen surplus. In the same vein, Cortignani et al. (2017) found that new crops introduced affect crop diversification on the farm with an increase of the Shannon Index. This is accompanied by a reduction in nitrogen use. As the main crops (durum wheat and maize) require a large amount of nitrogen, a reduction in the main crop area resulted in a decrease of nitrogen use.

As green payments intended to cover the cost of environmental goods production, its effects on the economic situation of farms is much of interest.In their study, Gocht et al. (2017) found a positive effect on income but a reduction of production. This result can be explained by the fact that there is an increase in the output price after the reform. As (some) lands are taken out due to compliance as shown by Olagunju et al. (2022), there is a reduction of output supply which affect the agricultural goods prices. Even though there is a negative production effect, the price effect outweighs it, resulting in an increase in the farm incomes. However, Cortignani et al. (2017) found a reduction of gross margins, but not related to the 2013 CAP reform. This reduction is mainly due to the convergence aspect within and between states. Coupled payment introduced by the reform seems to reduce negative effect on farm incomes. Louhichi et al. (2017) assessed the consequences of crop diversification measure at farm level using IFM-CAP. Using individual FADN data combined with FSS between 2007 and 2009, their results highlight a decline in the overall production change at EU-27 levels (0.4%) caused by the crop diversification measure of the greening with a variation between crops is observed, ranging from -1.5% to 0.11%. However, as opposed to Gocht et al. (2017), a small decrease of income level is also observed at EU level (maximum -0.35% in Finland). But more important effect on income is observed by farm specialisation and farm size. The results of Louhichi et al. (2018) demonstrate a decline of the total production of 0.9% at EU level. This decline is mainly attributable to the land allocation. At Members States (MS) level, there is a variation from 0 to -4.5%. The production change is higher for more specialised crop, but also for small and larger farms. The part of greening measure in the income decline is rather a small (1%) at EU-level. We can see that there is a consensus in the effect of 2013 CAP Reform on the production level, which mainly decline after the reform. However, the effect of the farm income is still debated.

Our study will only be focus on the effect of crop diversification. Therefore, the closest study to our is the one of Louhichi et al. (2017). However, we go beyond the economic and land use effect by also analysing the potential effect on the environmental dimension. In addition, we introduce a productivity measure, which is TE, to measure technical capacity and productivity change due to crop diversification requirements. The next section will develop on the link between crop diversification and crop production, productivity and inputs usage.

2.3 How Crop Diversification Impact Production and Productivity?

In the era of mechanisation and modernisation of agriculture, agricultural system have been simplified, causing heavy dependence on pesticides and fertilisers and preferring monocultures (Lithourgidis et al., 2011). These agricultural practices implied biodiversity degradation and environmental concerns (Tamburini et al., 2020). An appropriate management of agricultural system and crops is sought to solve many of the negative impact on the environment (Power, 2010). Crop diversity, as underlined by Bommarco et al. (2013), can be a key element of crop management intended to reduce negative effect while preserving crop yields. It can increase the efficiency use of inputs and resources at farm level via complementary of crops (Bommarco et al., 2013; Di Falco et al., 2010) but also be a buffer against weeds, diseases and pests (Lechenet et al., 2014).

Studies in France have documented a potential increase of production and yields due to crop diversification. Bareille and Letort (2018) showed that crop diversity increase yields of winter barley and wheat. Similar results have been found by Donfouet et al. (2017) who highlighted positive and significant influence of crop diversity on major crop production. Their results suggested also that the effect is more prominent in case of low rainfalls.

Crop diversity has been also identified as a key strategy to reduce price and production risk. Di Falco and Chavas (2009) showed that biodiversity reduce the effect on risk, especially when land is degraded in Ethiopia. Indeed, multiple crop allow farmers to sell their products many times per year. Moreover, as shown also by Donfouet et al. (2017), it can also enhance the agricultural production, especially when rainfall is low. This latter result is confirmed in Italy (Di Falco and Chavas, 2008) and in Ethiopia (Di Falco and Chavas, 2009; Di Falco et al., 2010).

However, the positive effect of crop diversity on production and productivity seems not to be unanimous. Zeng et al. (2020) found a inverted U-shaped effect on crop diversification on agricultural output in China. The effect is even negative for lower and median quartiles of the distribution. Moreover, when it comes to greening crop diversification effect on productivity and income, studies mainly converge toward a reduction of income (Louhichi et al., 2017; Cortignani et al., 2017; Solazzo and Pierangeli, 2016). One exception is the study of Gocht et al. (2017) which found positive effect on income, although a negative effect on production was highlighted.

Our study will evaluate the crop diversity effect on, among others, TE and EE. Crop diversity can modify these two outcomes via input use, i.e., modification of input quantity and requirement that depend on each crop, or via the output level, i.e., different level of production following the introduction of a new crop. Our estimation strategy will be altogether different from existing studies relying on production function (Di Falco et al., 2010), production function with spatial effect (Donfouet et al., 2017), simulation based on mathematical programming (Solazzo and Pierangeli, 2016; Louhichi et al., 2017; Mahy et al., 2015) or a dynamic acreage model (Bareille and Letort, 2018). In the next section, we will explain our econometric strategy.

3 Econometric Strategy

The existing literature on greening effects has mainly used simulations, mainly based on mathematical programming (Gocht et al., 2017; Cortignani et al., 2017; Louhichi et al., 2017), as a methodology to assess green payment effects. Therefore, it is more of an ex-ante method based on different scenarios. However, our studies rely on a quasi-experimental setting, namely the Diff-in Discontinuity, to identify the causal impact of the crop diversity criterion. Hence, we have an ex-post evaluation of the policy at hand.

The French FADN database allows us to identify farms receiving green payments each year. However, the EFA and permanent grassland criteria are hard to measure. Indeed, there is limited data on core elements of the EFA criterion in the FADN database and the maintenance of permanent grassland criterion is measure at regional level. This impedes the evaluation of the entire green payments system.

However, it is possible to identify farms for the crop diversity criterion as we have both data on arable land and main crop share. Therefore, our analysis will be focus on this precise criterion. The 2013 CAP reform creates a discontinuity around 10ha and 30ha that did not exist before 2013. It acts as a natural experiment, as it is an exogenous source of variation of the variable determining the treatment assignment (Meyer, 1995). Exploiting this setting will allow us to evaluate causal effect of crop diversity criterion. Thus, we can compare green payment receivers just below and just above the two thresholds. By selecting only farm households that receive green payments, we ensure that no bias is introduced[3].

We can think of a Regression Discontinuity Design (RDD hereafter) as an appropriate methodology. Indeed, the greening component of 2013 CAP reform implies different requirements for farmers that are respectively above and below 10 ha and 30 ha of arable land. The conditions for the crop diversity criterion are increasingly harder with arable land area. Farms above 10 ha have stronger requirements than farms below, same as farms above 30 ha compared to the one below[4]. Therefore, by comparing farm households just below and

[3]Comparing receivers and not receivers of green payments around the cut-off will generate a bias every farm can, in principle, receive the green payments by comply with different requirements.

[4]In fact, farms can receive green subsidies when they are below 10 ha of arable land. The reason behind this is the existence of exemptions. For instance, organic farms are exempted for the crop diversity criterion. Our sample does not include organic farming.

above thresholds, we will have the impact of crop diversity criterion on economic, environmental and land use conditions. Hence, the RDD could be well-suited for this case.

However, one key assumption in RDD is the continuity hypothesis, meaning that the treatment should be the only source of discontinuity around the thresholds. If we assume that farms just above cut-offs are similar to farms just below before the treatment, the expected outcomes of the two groups are considered to be the same before treatment (Hahn et al., 2001). One way of testing this hypothesis is to estimate an RDD on available covariates around the threshold. The results of this procedure are documented in Table B2 and Table B3. Around 10 ha, the general education level as well as the legal status are significantly different for farms above and below the threshold. The same observation is made for farms around 30 ha, as household head age is significant. These estimations highlight the threat in the identification strategy if we rely on cross-sectional RDD, as there are confounding factors. Therefore, this methodology is not suitable for our case.

To overcome this problem, we will take advantage of our database. Indeed, we have data before the CAP reform. This help us overcome the confounding effect from other sources of discontinuity by combining the before\after setting with the RDD. This approach has been studied in the literature and is called Difference-in-Discontinuity, DD hereafter, (Grembi et al., 2016).

The basic idea of the RDD is to evaluate treatment effect by comparing observations just above and below a known cut-off point (here 10 ha and 30 ha, respectively, of arable land). Indeed, in RDD setting, the assignment to the treatment or control group is determined whether the value of the forcing variable (here the arable land area) is greater than the known cut-off (Lee and Lemieux, 2010). Therefore, the known cut-off creates a discontinuity in terms of probability to be treated or not (Imbens and Wooldridge, 2009). This setup is combined with traditional difference-in-difference methodology. The before\after setting allows removing confounding effects, based on the assumption that the effect of confounding factors are constant over time in the absence of the treatment (Grembi et al., 2016). This assumption can be tested by verifying the local parallel trend for farms just below and above thresholds, had the CAP reform did not take place. A manipulation test, as described by

McCrary (2008) can also help check the plausibility of this hypothesis. As the probability to receive the treatment varies discontinuously across the two groups, we adopt the Sharp DD. This methodology has been used extensively lately to evaluate local treatment effect (Grembi et al., 2016; De Benedetto and De Paola, 2019; Chicoine, 2017, i.e.).

Following Grembi et al. (2016) and De Benedetto and De Paola (2019), the sample will be restricted to farms with arable land (L_{it}) in the interval $L_{it} \in [L_c - h, L_c - h]$ with L_c the running variable (arable land) and h the distance on either side of L_c computed via the optimal bandwidth estimator from Calonico et al. (2014) (CCT, henceforth). Based on Gelman and Imbens (2019), a local linear regression will be used, and the model can be specified as follows:

$$Y_{it} = \beta_0 + \beta_1 Arable^(10/30)_i + \beta_2 T_t + \beta_3 T_t * Arable\_(10/30)_i + \beta_4 X_{it} + \beta_5 L^*_{it} + \epsilon_{it} \quad (1)$$

where Y_{it} are different outcomes of interest described in Table 2 of the next section, T_t is the post-treatment indicator, $Arable\_(10/30)_i$ is the dummy variable which equals to 1 if farm arable land is higher than 10 ha, 30ha, respectively, and $L^*_{it} = L_{it} - L_c$ is the normalised arable land size, as in Lee and Lemieux (2010), Grembi et al. (2016) and De Benedetto and De Paola (2019), to account for the fact that the identification strategy relies on the exogeneity of the arable land (assignment variable) at the cut-off. Moreover, we add some farm and farmer characteristics such as the household head age and general and agricultural education level, a dummy equal to 1 if farm is located in less favoured area, a dummy equal to 1 if farm is located in an environmental constraint area and the legal status of farms, all encompassed in X_{it}. The sample on which we run our estimation will be presented in the next section.

4 Data

4.1 Data Description

In this study, we rely on the French Farm Accountancy Data Network (FADN) data. FADN data contains detailed statistical data on farm characteristics and income each year. The FADN is a rotation, unbalanced, panel as selected farmers are different through years. Around

10% of the sample is yearly renewed, but some farms maybe observed once or multiple successive years (Piet et al., 2020). Farmers are classified according to their location at a regional level (NUTS2), their type of farms (TF) but also to their economic dimension. FADN data is focused on commercial farms, as economically small farms are excluded[5]. The total farm surveyed range from 7000 to 7500 farms and is representative of the French commercial farms. It also contains the subsidies received through the 1st pillar of the CAP and the greening subsidies. Therefore, we are able to identify specifically those who receive green payments, i.e., the compliers with the greening requirements of the 2013 CAP reform.

Our sample is composed of green payments receivers, excluded organic farming. The latter are excluded because they are exempted of the crop diversity requirement and therefore, there is no additionality in terms of agricultural practices. Data from 2012 to 2018 are used to analyse the effect of 2013 CAP reform. These data concern metropolitan France. This period of time allows us to have a before-after comparison of the reform which took place in 2013. The final database is a pooled sample of roughly more than 21000 farms. This final database allows us to derive our outcome of interest, explained in detail in the next subsection.

Table 1 presents descriptive statistics for farms which received green payments from 2015 to 2018 and the one which did not.

Table 1: Descriptive Statistics according to greening subsidies from 2012 to 2018

Variables	Greening					No greening				
	N	mean	sd	min	max	N	mean	sd	min	max
Shannon Index	10645	0.73	0.18	-0.11	1.06	157	0.67	0.23	0.18	1.05
Arable land	13523	91.48	79.82	0	704.23	1221	3.85	23.89	0	383
UAA	13523	124.69	84.25	0	833.64	1221	23.49	32.93	0	413
Gross Production	13523	230423.16	237256.61	2045.24	4027001	1221	402505.97	443417.61	1475.97	4067182
Technical Efficiency	13523	0.68	0.15	0.07	0.99	1221	0.71	0.17	.07	0.99
Number of crop	13523	3.95	2.12	0	14	1221	0.21	0.85	0	9
Share of main crop	13523	0.46	0.23	0	1	1221	0.05	0.18	0	1
First Pillar Subsidies	13523	30035.84	20673.9	9	175810.2	1221	327.07	4270.64	0	81282
1 if Breeding	13523	0.61	0.49	0	1	1221	0.09	0.28	0	1

The first important aspect is the relative low number of farms that did not receive any green payment. Among the 14744 farms in the sample from 2015 to 2018, only 8.28% of them did not receive green payment. In order words, 8.28% of the farms in the sample did not meet the minimum criteria in terms of crop diversity, share of permanent grassland and ecological

[5] Farmers that have less than 25000 € of Standard Gross Production are not taken into account.

focus area (EFA). The second feature of the comparison between the two groups is the higher size in terms of UAA and arable land of green payments receivers. Indeed, the average UAA and arable land are, respectively, 124.69 ha and 91.48 ha for receivers against 3.85 ha and 23.49 ha. However, gross production and technical efficiency are higher for non-receivers, in average, than their counterparts. We can see also that farms which did not receive green payments tend to receive much less first pillar subsidies than the receivers.

Table B1 highlight differences between farms around 10ha and farms around 30 ha of arable land. Farms between 10 ha and 30 ha have, on average, almost 1000 € more green subsidies than farms beneath 10 ha. The same observation can be made for farmers between 10 ha and 30 ha, and the one above 30 ha. The gross production, i.e., output, is higher for farmers below 10 ha but farmers above 30 ha are more technically efficient than the others. An interesting feature is the share of the main crop and the share of the two main crops. For all groups, the share of the main crop is lower than 75%, which is the criterion of the greening component of the CAP, and the share of the two main crops is also lower than 95% (European Court of Auditors, 2017). This might suggest that farms of all groups, on average, would meet the crop diversity criterion if the greening component relied only on it.

4.2 Outcome of Interest

In this study we are interested in the economic, environmental and land use effects of the greening crop diversity criterion. We have multiple outcomes for each of these dimensions. Table 2 presents the definition of outcome variable used and details about the computation. Our technical (TE) and environmental efficiency (EE) indicators are computed following Reinhard et al. (1999, 2002). This method is based on Stochastic Frontier Analysis (SFA) with a production function linking the output produced with inputs used at hand (Battese, 1992). The stochastic production frontier can be written as follows (Reinhard et al., 1999):

$$Y_{it} = f(X_{it}; Z_{it}; \beta) \cdot \exp\{V_{it} - U_i\}, \tag{2}$$

Where

- Y_{it} is the level of production for farm i at time$t$,
- X_{it} is a vector of conventional inputs. The inputs variables are: fixed assets (x_{it1}), Utilised Agricultural Area (x_{it2}), Agricultural Working Unit[6] (AWU° in the farms (x_{it3}) and Intermediary Consumption (x_{it4});
- Z_{it} is a environmental detrimental input. It is represented by expenses of crop protection and fertilisers;
- β is a vector of technology parameters;
- V_{it} is the random error terms measuring the effects of statistical noise and is assumed to be independently and identically distributed (i.i.d) of $N(0, \sigma_v^2)$ distribution;
- U_i is the non-negative random error term which measures the inefficiency. It is assumed to be i.i.d. of $N^+(\mu, \sigma_v^2)$.

A functional form can be specified via a translog function à la Christensen et al. (1973), which gives us the following expression :

$$
\begin{aligned}
lnY_{it} = \beta_0 & \\
& + \sum_{j=1}^{4} \beta_j lnX_{kit} + \beta_z lnZ_{it} \\
& + \frac{1}{2} \sum_{j=1}^{4} \sum_{k=1}^{4} \beta_{jk} lnX_{ijt} * lnX_{ijk} \\
& + \sum_{j=1}^{4} \beta_{jz} lnX_{ijt} * lnZ_{it} \\
& + \frac{1}{2} \sum_{k=1}^{4} \beta_{zz} (lnZ_{it})^2 + V_{it} - U_i
\end{aligned} \tag{3}
$$

.

From Equation 3, a technical efficient farm will have $U_{it} = 0$, meaning that he operates on the frontier. From this point, the environmental efficiency (EE) can be derived. EE is expressed here as the ratio of minimum feasible quantity of the detrimental input, i.e. Z_{it}^F,

[6] One unit of AWU amounts to 1600 hours.

to actual quantity used by the farm Z_{it} ($EE = Z^F_{it}/Z_{it}$) (Reinhard et al., 1999). Therefore, EE is the ability of farm to reach the minimum of crop protection and fertiliser expenses given the level of output. (Reinhard et al., 1999) uses a non-radial notion, meaning that it is a single factor measure of farm efficiency in the use of detrimental input. The logarithm of an environmental efficient producer is obtained by replacing $U_i = 0$ and $Z_{it} = Z^F_{it}$ with Z^F_{it} the minimal feasible environmentally detrimental input. It gives us the following translog form:

$$\begin{aligned} lnY_{it} = {} & \beta_0 \\ & + \sum_{j=1}^{4} \beta_j lnX_{kit} + \beta_z lnZ^F_{it} \\ & + \frac{1}{2} \sum_{j=1}^{4} \sum_{k=1}^{4} \beta_{jk} lnX_{ijt} * lnX_{ijk} \\ & + \sum_{j=1}^{4} \beta_{jz} lnX_{ijt} * lnZ^F_{it} \\ & + \frac{1}{2} \sum_{k=1}^{4} \beta_{zz} (lnZ^F_{it})^2 + V_{it} \end{aligned} \tag{4}$$

The EE can be deduced by setting Eqs. (3) = (4), which gives us:

$$\frac{1}{2}\beta_{zz}\left(lnZ^F_{it} - lnZ_{it}\right)^2 + \left(lnZ^F_{it} - lnZ_{it}\right)\left[\beta_z + \sum_{j=1}^{m} \beta_{jz} \ln X_{ij,t} + \beta_{zz} \ln Z_{i,t}\right] + U_{i,t} = 0 \tag{5}$$

with $lnEE = lnZ^F_{it} - lnZ_{it}$.

The resolution of Equation 5 allows us to obtain the final expression of the EE :

$$\ln EE_{i,t} = \left[-\left(\beta_z + \sum_{j=1}^{m} \beta_{jz} \ln X_{ij,t} + \beta_{zz} \ln Z_{i,t}\right) \pm \left\{ \left(\beta_z + \sum_{j=1}^{m} \beta_{jz} \ln X_{ij,t} + \beta_{zz} \ln Z_{i,t}\right)^2 - 2\beta_{zz} U_{i,t} \right\}^{0.5} \right] \beta_{zz}. \tag{6}$$

Whereas the TE is estimated econometrically, the EE is calculated via Equation 5 from parameters already estimated (β_z and β_{zz}) and the inefficiency term U_{it} (Reinhard et al., 1999; Marchand and Guo, 2014).

Above the TE and EE, other indicators are computed for our three dimensions. The details of their computation can be found in Table 2. The next section will present the results of our estimations.

Table 2: Definition and computation details of outcome variable

Dimension	Name	Description	Details
Environment	eveness	Shannon Index	Shannon Index is computed as follows: eveness $= -\sum_{i=1}^{s} p_i \ln p_i$ where p_i is the proportion of n_i crop over the total number of crops N. The lower limit is 0 meaning that there is no diversity in the farm.
	EE	Environmental Efficiency	The Environmental Efficiency is derived from the computation of Technical Efficiency (TE) based on Reinhard et al. (1999) formula. The environmental detrimental input used is the expenses in fertilisers and crop protection.
	raten	Fertiliser use ratio	We compute first fertiliser consumption by deducing inventory change to the fertilisers expenses. Then, we divide this by the UAA to obtain the consumption per ha of the farm. The latter is now compared to the average consumption per ha of the farms' TF. If the ratio is greater than 1, then the farm is using more fertiliser per ha than the average of it peers, suggesting more devastating impact compared to its peers. Midler et al. (2019) and Kirsch (2017) used approximately the same method, but they did not divide it by the average of the TF.
	ratph	Crop protection use ratio	Same as the fertiliser use ratio.
Economic	TE	Technical Efficiency (TE)	TE is computed with stochastic frontier analysis (SFA) following Reinhard et al. (1999). We choose a translog (Christensen et al., 1971, 1973) specification over a Cobb-Douglass because of its flexibility (Corbo and Meller, 1979). The agricultural production is the output. Four inputs are chosen : the Utilised Agricultural Area (UAA), the number of Agricultural Working Unit, the fixed assets and the intermediate consumption.
	ebe_uta	Operating Surplus per unpaid workers.	It is the ratio between operating surplus and unpaid workers. The unpaid workers in the French FADN are the associate of the farm head. Therefore, It is divided by the unpaid workers to account for the real profitability of the farm when the associates are not considered (Piet and Desjeux, 2021).
	rcai_uta	Income before tax per unpaid workers	The ratio between income before tax and unpaid workers.
Land Use	part_dom	Main crop share	The French FADN gives us the area dedicated to each crop. Therefore, we divide each area by the UAA and then derive the main crop share as the maximum.
	part_dom2	Two main crop share	Same procedure as the main crop share, except here it is the share of the two main crop.
	nb	Number of crop	Number of crops cultivated by the farm.

5 Results

In this section, we present, first, our results pertaining to the crop diversity effect for the entire sample. Second, we evaluate the potential effect of the crop diversity criterion for farms that did not meet the requirements in 2014.

5.1 What is the Effect of Green Payments Crop Diversity Criterion?

We start by presenting the results of crop diversity criterion on different economic, environmental and land use outcomes. All these farms have received the green payments. Therefore, comparing farms around the two threshold helps us identify the proper effect of the crop diversity criterion. Table 3, Table 4 and Table 5 present results of crop diversity criterion around 10 ha.

Table 3: Green payments effects around 10 ha: Environment

	EE	Shannon Index	Fertiliser Index	Crop Pro. Index
LATT	-0.001	-0.081	-0.218	-1.841
	(0.167)	(0.207)	(1.928)	(2.982)
Total.ob	303	134	384	221
Bandwidth	4.989	4.431	7.000	6.464

Note:Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

Table 4: Green payments effects around 10 ha: Land use

	Main crop share	Two Main crop share	Number of crop
LATT	-0.111	-0.057	0.715
	(0.099)	(0.053)	(0.452)
Total.ob	434	307	365
Bandwidth	4.866	3.598	4.115

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

Table 5: Green payments effects around 10 ha: Economic

	TE	Operating Surplus	Income before tax
LATT	0.050	52.818	-98.312
	(0.063)	(91.497)	(79.868)
Total.ob	444	460	402
Bandwidth	4.503	4.972	4.940

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

For farmers around 10 ha of arable land, the green payment did not have any significant effect in all three dimensions, namely environmental, economic and land use. In order terms, the requirement of the crop diversity criterion around 10 ha did not translate into any significant changes in economic, environmental and land use situations. Louhichi et al. (2017) found quite similar results, with median farms being more affected by the crop diversification and small farms being affected to a smaller extent. A possible explanation of these results could be the fact that farms around this threshold have already been compliers with requirements, meaning their agricultural practices matched the requirement of the criterion even before 2014. It means that there are probably windfall effects. France has one of the highest numbers of non-compliers with crop diversity requirement in the EU, but is dominated by large farms or farms with high arable land (Louhichi et al., 2017). Therefore, it is possible that small farms have already met crop diversification requirements. Another possible explanation is the farm structure of these farms. Compared to larger farms, small farms have a less diversified production structure.

Table 6, Table 7 and Table 8 report results around 30 ha. As for farmers around 10ha of arable land, no significant effect of crop diversification is found for environmental and land use situation.

Table 6: Green payments effects around 30 ha: Environment

	EE	Shannon Index	Fertiliser Index	Crop Pro. Index
LATT	0.048	-0.003	0.604	-0.638
	(0.079)	(0.062)	(1.132)	(0.813)
Total.obs	450	650	282	335
Bandwidth	4.732	5.726	5.349	4.466

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

Table 7: Green payments effects around 30 ha: Land-use

	Main crop share	Two Main crop share	Number of crop
LATT	0.064	0.056	0.211
	(0.064)	(0.053)	(0.413)
Total.obs	924	958	894
Bandwidth	6.106	6.048	5.787

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

However, crop diversity requirement have reduced significantly TE and operating surplus per unpaid workers. Therefore, diversification following CAP reform have reduced productivity and income of farms above 30ha. The effect on TE can be explained by the fact that

Table 8: Green payments effects around 30 ha: Economic

	TE	Operating Surplus	Income before tax
LATT	-0.075*	-202.430*	-9.501
	(0.042)	(105.973)	(73.691)
Total.obs	819	480	879
Bandwidth	5.296	3.697	5.292

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

the requirement may involve reallocation of crop share. Therefore, crop with large share before the reform will tend to be reduced and crop with low share will tend to increase (Louhichi et al., 2017). More importantly, an additional crop requires knowledge on input use, nutriment, markets values, etc (Haji, 2007). This might introduce some complexity in the production structure. Moreover, subsidies received may distort farms' behaviours. Indeed, as farms operate under uncertainty, Hennessy (1998) showed that decoupled payment like greening subsidies can induce a wealth and insurance effect. This is particularly true as greening subsidies intend to cover cost related to environmental goods production (European Union, 2013). The wealth effect, which was found to exist for 2003 Mid-Term Review of the CAP by Sckokai and Moro (2006), can reduce the risk aversion and then change farms behaviours in terms of input use or output production (Zhu and Lansink, 2010). The insurance effect can also have the same effect (Martinez Cillero et al., 2021). All these factors can contribute to explain the TE result.

The income effect confirms results of most previous studies (Louhichi et al., 2017; Cortignani et al., 2017; Solazzo and Pierangeli, 2016; Cimino et al., 2015) but goes against the one of Gocht et al. (2017). As put forward by Louhichi et al. (2017), the income effect can be a result of the productivity effect, which impact production sales and margins. It is worth noting that the operating surplus per unpaid workers takes into account greening subsidies. It means that these subsidies did not compensate the negative effect of productivity, as it was also found by Cimino et al. (2015) in Italy.

5.2 Heterogeneity

Our main results can be driven by systematic difference between farms. Indeed, production structure varies, for instance by the type of farming. The capacity to comply with the requirement might differ whether farms are more related to breeding than crop production. Therefore, we separate our sample between two groups: breeding farms and crop farms [7]. .... and ... present the results for farms around 30 ha [8]. We can see that crop farms

These results can be influenced by the fact that greening requirement was mainly designed to have many compliers, as underlined by Cortignani et al. (2017) and Louhichi et al. (2017). This might create a targeting problem, especially if many farms have already requirements before the reform. In the next section, we will focus only on farms that did not meet the requirement of crop diversification and see if there might be a change in results.

5.3 Were crop diversity criteria designed to fail?

The precedent results reinforce the idea that green payment have had, if any, little effect on economic, environmental and land use conditions. Indeed, the crop diversity criterion worsen even economic condition of farm around 30ha while having no significant effect on land use and environmental aspect. One of the possible reason is the fact that most of the green payments receivers might have already met crop diversity requirements. Therefore, the crop diversity criterion did not bring any additionality in terms of agricultural practices.

However, this raise an interesting question: would it be different if the crop diversity were only focused on farms that did not meet the requirements? Indeed, one might argue that green payment and particularly the crop diversity criterion did not meet up one's expectations because of the poor targeting mechanism. This argument implies that a change of target, i.e. selecting farms which did not meet the criterion, might be efficient. We intend to verify this stance. Our database allows us to identify farms that did not respect the crop diversity criteria and receive green payments in the 2015-2016 period. Therefore, we restrict our database to those "non-compliers". Then, we estimate the effect of the crop diversity

[7] explaining the classification.

[8] There were not enough observation to run estimation around 10 ha after the separation.

criterion around 30ha[9]. The results will provide an overview about the potential effect of the crop diversity criterion, have it been targeted toward the non-compliers.

The results indicate a significant reduction of the crop protection index and significant increase of two main crop share. In others words, the crop diversification criterion would have reduced the intensity of crop protection expenses and would have increase the two main crop share around 30ha, have it been targeted only farms that did not meet requirements.

Table 9: Green payments effects around 30 ha: Environment

	EE	Shannon Index	Fertiliser Index	Crop Pro. Index
LATT	0.059	0.105	2.326	-1.763*
	(0.077)	(0.101)	(1.769)	(0.968)
Total. obs	129	169	135	159
Bandwidth	4.402	6.309	4.962	4.484

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

Table 10: Green payments effects around 30 ha: Land-use

	Main crop share	Two Main crop share	Number of crop
LATT	0.079	0.158*	-0.298
	(0.095)	(0.083)	(0.464)
Total. obs	373	379	373
Bandwidth	5.59	5.990	5.643

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

Table 11: Green payments effects around 30 ha on non-compliers: Economic

	TE	Operating Surplus	Income before tax
LATT	0.031	130.168	163.433
	(0.056)	(114.010)	(106.238)
Total. obs	446	369	384
Bandwidth	6.663	5.819	5.893

Note: Robust standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01.

Moreover, the negative income effect found earlier would not have been observed. The explanation would have been due to the land reallocation on the farm, with more crop share

[9]Estimation around 10ha of arable land could not be possible because of the limited number of observation left. This means probably that, it might exist windfall effect around 10ha, but we are unable to quantify it.

increase due to requirements. The reduction of the crop protection index could have been explained by the potential low requirement of new crop introduced or the benefit from crop diversity with efficiency in input use as shown in the literature Di Falco et al. (2010); Bommarco et al. (2013); Lechenet et al. (2014).

These results seem very interesting in public policies perspective. Indeed, that better environmental results and no detrimental income effect could have been avoided if crop diversity criterion targeted non-compliers.

6 Robustness

To test the robustness of our results, we decide to change some aspects in our main estimation. First, we choose a different bandwidth following Ludwig and Miller (2007) cross-validation bandwidth estimator (CV, henceforth) instead of the CCT bandwidth estimator for the main results. New bandwidth obtain are greater than CCT bandwidth.

Second, we choose other thresholds for our estimation. As the 2013 CAP reform exacts different requirement only around 30ha and 10ha (and 15ha for the EFA criterion), choosing different bandwidth should lead to no significant effect between farms. Therefore, we run estimation for the following bandwidth : 35ha, 40ha and 45ha.

7 Conclusion

Green payments of the 2013 CAP reform intended a better inclusion of the environment without comprising the economic aspect of the farm. Its main objective was to remunerate farms for the provision of environmental services. The main objective was to support farms in the production of environmental goods. The crop diversification criterion introduces different requirement for farms around two thresholds of arable land. Farms above 10ha and 30 of arable land have higher constraints than, respectively, farms below 10ha and 30ha. In this study, we aim to answer two questions. First, what was the effect of the crop diversification criterion on environmental, economic and land-use conditions of farms? Second, were the crop diversification criterion designed to fail? We enrich previous studies on this literature in multiple way. First, this is, to the best of our knowledge, the first evaluation of crop diversification criterion using impact evaluation technique. Second, this is also the first study evaluating greening crop diversity criterion on technical and environmental efficiency computed via SFA methods. Third, this study offers a broad view by analysing effect on three dimensions, namely environmental, economic and land-use. Finally, this is the first study that we are aware of, dealing with crop diversification effect on these three dimensions in France.

Using data from French FADN for the 2012-2018 period, we found, first, that the crop diversification criterion itself did not translate into any significant changes for farmers around 10 ha of arable land. However, negative income and productivity effect have been noticed for farms around 30ha. The results are in line with most of previous studies that also found negative income effects (Louhichi et al., 2017; Cortignani et al., 2017; Cimino et al., 2015; Solazzo and Pierangeli, 2016).

Second, our results showed evidence of windfall effects presence, meaning a situation where farms receive subsidies to adopt practices that they would have adopted in the absence of the policy. Indeed, we found a reduction of the crop diversity index and an improvement of the two main crop share around 30ha, when estimation is done only farms that did not meet requirements. These results imply that better environmental and land use results as well as no detrimental income effect could have been obtained, had the crop diversity criterion been targeted to farms that did meet the requirement before the implementation of the policy.

In the light of these findings, interesting policy implication can be derived. Indeed, the design of the crop diversification criterion have shown to have fail to live up with expectations. Better results could have been achieving with a finer targeting mechanism. Therefore, public policies aiming to encourage crop diversity could be more specific by setting requirement only on farms with different agricultural practices than the one aimed. This might bring more additionality and might lead to better outcomes. Farms that have already met the requirement could be exempted. Another implication is the absence of significant change for farms around 10 ha. This might be due to the inherent limited production structure that is a constraint when it comes to diversification. Therefore, future policies pertaining to crop diversification might privilege medium and larger farms in terms of agricultural area.

This paper has some limits that should be taken into account. For instance, we were not able to evaluate heterogeneous effect through the types of farming. Also, we were able to quantify windfall effect around 10ha. Nonetheless, the results of this paper constitute new evidence pertaining to the crop diversification. These results can help policy-makers, especially for the following CAP reforms.

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8 Appendices

AppendixA Graphs

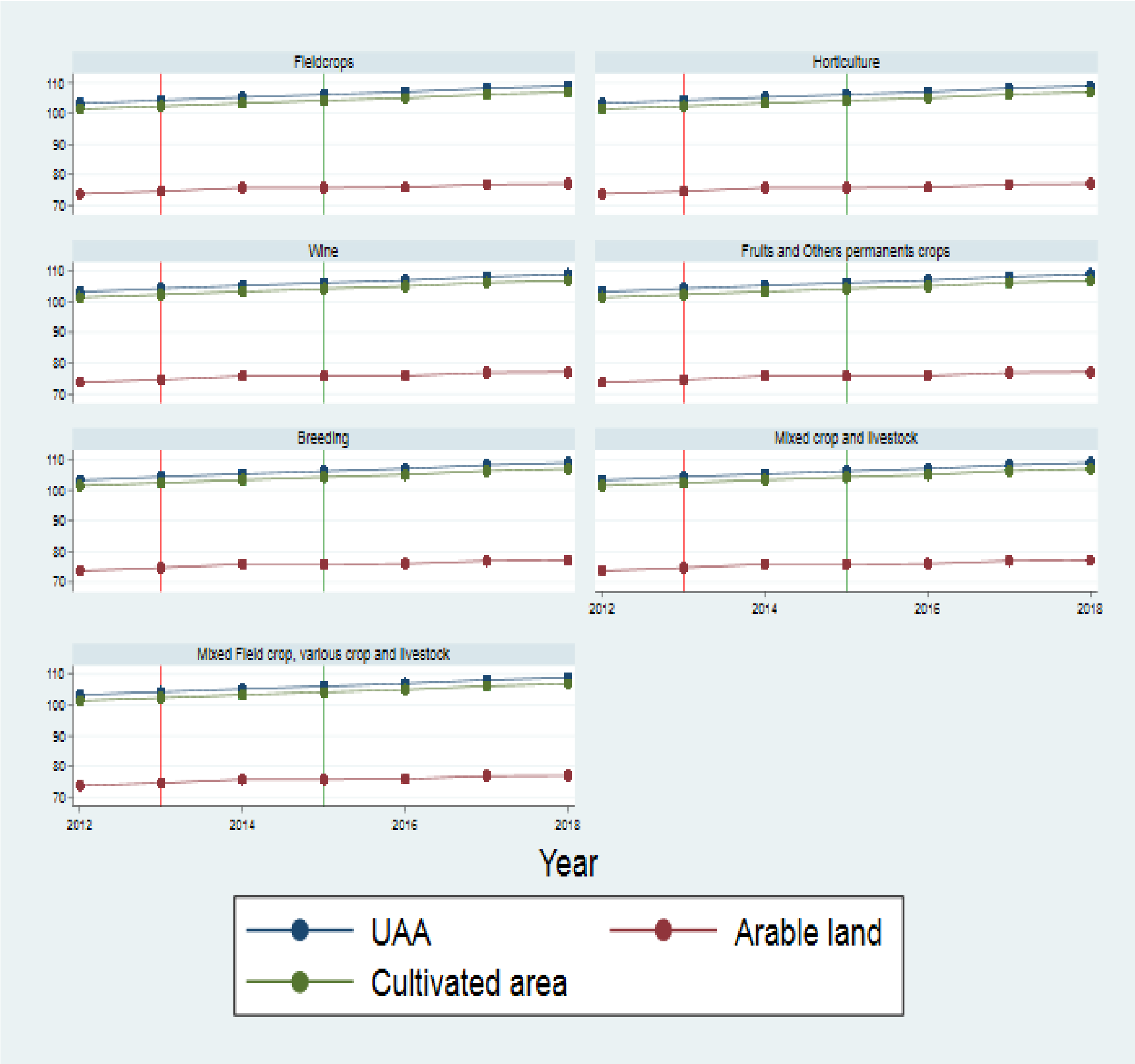

Figure A1: UAA, Cultivated area and Arable land per TF by year in France

AppendixB Additional Descriptives Statistics

Table B1: Descriptive Statistics around 10ha and 30ha of arable land

Around 10ha of arable land

Lower than 10ha				Between 10ha and 30ha			
Variables	N	mean	sd	Variables	N	mean	sd
Arable land	6651	0.9	2.31	Arable land	2614	20.39	5.71
Green Subsidies	2786	971.73	1350.49	Green Subsidies	1436	1969.11	1215.29
Gross Production	6651	257601.45	321630.23	Gross Production	2614	160087.91	191180.24
Operating surplus/unpaid workers	6651	62641.25	106842.68	Operating surplus/unpaid workers	2614	49475.07	58626.12
Income before tax/unpaid workers	6651	36538.4	100660.51	Income before tax/unpaid workers	2614	25164.85	48871.96
Shannon Index	993	0.64	0.26	Shannon Index	1635	0.65	0.22
Technical Efficiency	6651	0.68	0.18	Technical Efficiency	2614	0.64	0.16
Share of main crop	6651	0.12	0.3	Share of main crop	2614	0.59	0.22
Share of the two main crops	6651	0.15	0.36	Share of the two main crops	2614	0.83	0.21

Around 30ha of arable land

Between 10ha and 30ha				Higher than 30ha			
Variables	N	mean	sd	Variables	N	mean	sd
Arable land	2614	20.39	5.71	Arable land	18612	113.49	74.85
Green Subsidies	1436	1969.11	1215.29	Green Subsidies	10522	2960.02	1749.19
Gross Production	2614	160087.91	191180.24	Gross Production	18612	248412.47	238222.82
Operating surplus/unpaid workers	2614	49475.07	58626.12	Operating surplus/unpaid workers	18612	63330.68	69371.79
Income before tax/unpaid workers	2614	25164.85	48871.96	Income before tax/unpaid workers	18612	27961.28	56276.03
Shannon Index	1635	0.65	0.22	Shannon Index	16561	0.74	0.16
Technical Efficiency	2614	0.64	0.16	Technical Efficiency	18612	0.7	0.14
Share of main crop	2614	0.59	0.22	Share of main crop	18612	0.48	0.17
Share of the two main crops	2614	0.83	0.21	Share of the two main crops	18612	0.71	0.17

Table B2: Covariate Balance in RDD for farmers around 10ha of arable land

	Before 2013 CAP Reform					
	agech	genfo	agrfo	zdefa	zenvi	fjuri
Conventional	-1.531	-0.171**	-0.131	0.041	-0.021	0.349**
	(1.465)	(0.072)	(0.118)	(0.101)	(0.037)	(0.166)
Bias-corrected	-0.045	-0.203***	-0.162	0.080	-0.007	0.519***
	(1.465)	(0.072)	(0.118)	(0.101)	(0.037)	(0.166)
Robust	-0.045	-0.203**	-0.162	0.080	-0.007	0.519**
	(2.102)	(0.101)	(0.185)	(0.147)	(0.049)	(0.223)
Tot.Obs	2802.000	2802.000	2802.000	2802.000	2802.000	2802.000
Eff.Obs	555.000	2411.000	2415.000	569.000	2658.000	2639.000
Bandwidth	7.596	10.812	10.862	7.779	16.535	16.007

	After 2013 CAP Reform					
	agech	genfo	agrfo	zdefa	zenvi	fjuri
Conventional	-0.147	-0.157**	-0.185	0.063	0.046	0.241
	(1.062)	(0.067)	(0.123)	(0.084)	(0.042)	(0.155)
Bias-corrected	0.437	-0.182***	-0.297**	-0.003	0.029	0.321**
	(1.062)	(0.067)	(0.123)	(0.084)	(0.042)	(0.155)
Robust	0.437	-0.182**	-0.297	-0.003	0.029	0.321
	(1.462)	(0.088)	(0.184)	(0.115)	(0.055)	(0.224)
Tot.Obs	5185.000	5185.000	5185.000	5185.000	5185.000	5185.000
Eff.Obs	4661.000	1033.000	1105.000	796.000	1158.000	1268.000
Bandwidth	13.180	7.773	8.273	6.096	8.643	9.664

N.B: Standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01. *agech* = Household head age, *genfo* = General training, *agrfo* = Agricultural training, *zdefa* = 1 if farm is located in less favooured area, *zenvi* = 1 if farm is located in environmental constraint area, *fjuri* = Juridical status.

Table B3: Covariate Balance in RDD for farmers around 30ha of arable land

	Before 2013 CAP Reform					
	agech	genfo	agrfo	zdefa	zenvi	fjuri
Conventional	2.808**	-0.064	0.001	0.009	-0.042*	0.024
	(1.099)	(0.053)	(0.075)	(0.065)	(0.025)	(0.144)
Bias-corrected	4.503***	-0.003	0.012	0.057	-0.042*	0.138
	(1.099)	(0.053)	(0.075)	(0.065)	(0.025)	(0.144)
Robust	4.503***	-0.003	0.012	0.057	-0.042	0.138
	(1.728)	(0.078)	(0.107)	(0.092)	(0.036)	(0.233)
Tot.Obs	6211.000	6211.000	6211.000	6211.000	6211.000	6211.000
Eff.Obs	1412.000	2028.000	1872.000	1553.000	1830.000	1859.000
Bandwidth	15.197	25.189	21.584	17.253	20.581	21.223

	After 2013 CAP Reform					
	agech	genfo	agrfo	zdefa	zenvi	fjuri
Conventional	1.521**	0.011	-0.037	0.178***	0.008	-0.226*
	(0.754)	(0.043)	(0.063)	(0.061)	(0.024)	(0.120)
Bias-corrected	2.028***	0.048	-0.048	0.229***	0.038	-0.250**
	(0.754)	(0.043)	(0.063)	(0.061)	(0.024)	(0.120)
Robust	2.028*	0.048	-0.048	0.229***	0.038	-0.250
	(1.061)	(0.057)	(0.083)	(0.084)	(0.036)	(0.166)
Tot.Obs	11976.000	11976.000	11976.000	11976.000	11976.000	11976.000
Eff.Obs	3526.000	3542.000	3453.000	2063.000	2672.000	2423.000
Bandwidth	22.600	22.958	21.703	12.356	15.803	14.241

N.B: Standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01. *agech* = Household head age, *genfo* = General training, *agrfo* = Agricultural training, *zdefa* = 1 if farm is located in less favooured area, *zenvi* = 1 if farm is located in environmental constraint area, *fjuri* = Juridical status.