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Alexandre Sauquet

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Abstract

In this article, we quantify the impact of the crop diversification measure implemented in France as part of the 2013 Common Agricultural Policy (CAP) greening reform. We exploit a discontinuity in the constraints imposed on farms larger and smaller than 30 ha, respectively, and apply regression differences-in-differences with a regression discontinuity setup on land use data collected from a representative sample of French farmers. We find that farms greater than 30 ha increased compliance with the measure and the number of crops grown on their lands and that farms larger and smaller than 30 ha responded differently to the reform.

Keywords: Common Agricultural Policy; Greening; Crop diversification; France; Regression discontinuity design; Differences-in-differences.

JEL: Q15; Q18; Q25; Q28; Q53.

*CEE-M, Univ Montpellier, CNRS, INRAE, Institut Agro, Montpellier, France. Email: alexandre.sauquet@inrae.fr. *Acknowledgments:* We thank Clarisse Samson and Gabriela Demarchi for their excellent research assistance, as well as Julie Subervie for her valuable input at various stages of this project and Sophie Thoyer, Pauline Lecole, and Claudia Kelsall for their interesting comments. We are grateful to Shannon Harvey for English language editing. We thank the Agropolis and Cariplo foundations for financial support through the Caption project ("Investissements d'avenir" program, Labex Agro: ANR-10-LABX-0001-01, I-SITE MUSE: ANR-16-IDEX-0006).

1 Introduction

In recent decades, the intensification of agriculture in Europe has caused serious environmental and public health issues. One popular policy approach to reducing the adverse impacts of agricultural activity is the use of 5-year contracts called "agri-environmental schemes" (AES), which subsidize farmers for voluntarily adopting environmentally friendly practices. Since 1992, this type of incentive-based policy has been employed in the second pillar of the European Union (EU)'s Common Agricultural Policy (CAP).

The 2013 CAP reform that entered into force in 2015 introduced a small revolution, as an incentive-based policy encouraging environmentally friendly practices was also present in the first pillar of the CAP. The reform stipulated that 30 percent of a farmer's first pillar payment would be conditional on satisfying three agri-environmental criteria: crop diversification, maintenance of permanent grassland areas, and allocation of land to Ecological Focus Areas (EFAs).

While numerous studies have attempted to evaluate the impact of this reform, most have employed simulation models calibrated using the farm accountancy data network (FADN) to derive their predictions. Some studies have focused on a specific country or crop (Czekaj *et al.*, 2013; Solazzo *et al.*, 2014; Cimino *et al.*, 2015; Vosough Ahmadi *et al.*, 2015; Solazzo & Pierangeli, 2016; Cortignani *et al.*, 2017; Cortignani & Dono, 2019), while others have provided results for all or at least a broad set of EU member states (Van Zeijts *et al.*, 2011; Mahy *et al.*, 2015; Gocht *et al.*, 2017; Louhichi *et al.*, 2017a,b). Depending on the country in question, studies have predicted that 0 to 25 percent of eligible farms will change their land use to increase compliance with the crop diversification measure. In the case of France, Louhichi *et al.* (2015, 2017a) estimate that 7.3 percent of eligible French farms will do so.

Simulation models are very useful for predicting the impact of a reform. Nevertheless, models are typically calibrated using pre-reform data and rely on simplified behavioral assumptions (such as maximization of the expected utility of future profits) and exogenous parameters and do not integrate all the information on farmers' behavioral responses to financial incentives (Colen *et al.*, 2016; Erjavec & Lovec, 2017). When post-reform data are available, one alternative to employing simulation models to evaluate the impact of a policy is to use statistical analyses. Ex post impact analyses carried out by econometric methods are particularly suitable for this purpose as they do not require behavioral assumptions, since the complexity of farmers' decision-making mechanisms is taken into account thanks to the choice of an appropriate identification strategy. The challenge for causal inference is to develop credible estimates of what the outcomes would have been for the treatment group in the absence of the treatment.

There are various strategies for attempting to draw causal inferences from observational data (Athey & Imbens, 2017). One of these strategies is regression discontinuity design (RDD). In RDD, units are assigned to a treatment based on whether the value of an observed covariate exceeds a known cutoff. An estimation of the causal effects of a measure can be made by comparing observations in the neighborhood of the cutoff. Such is the case with the greening crop diversification measure, whose requirements differ between farms with more than 30 ha of arable land and those with less than 30 ha. Another strategy is a differences-in-differences (DD) analysis. The assumption underlying DD analysis is that the change in outcomes over time for the control group informs what the change would have been for the treatment group in the absence of the treatment.

A few ex post analyses have used the strategies discussed in Athey & Imbens (2017) and focused on AES from previous CAP reforms (Chabé-Ferret & Subervie, 2013; Arata & Sckokai, 2016; Kuhfuss & Subervie, 2018). These studies are important, as AES are a major transition tool and employ the highest share of the EU's public budget allocated to rural development programs. Nevertheless, AES represent only 4 percent of EU-CAP spending, whereas greening measures represent about 25 percent (European Court of Auditors, 2017; European Commission, 2021). Evaluating the impact of greening reform is thus of primary importance in future policy design and accountability in public spending. The only ex post analyses of greening measures conducted to date used aggregated data (Díaz-Poblete *et al.*, 2021) or Markov chain approaches (Bertoni *et al.*, 2018, 2021). Our contribution is to propose the first ex post evaluation of the CAP greening reform at the farm level using causal inference methods.[1]

[1] Díaz-Poblete *et al.* (2021) used data at the regional level (17 in Spain), which did not permit an evaluation of how farms individually responded to the reform. The Markov chain approaches used in Bertoni *et al.* (2018, 2021) are interesting and original but are not considered by Athey & Imbens (2017) to be among the strategies that allow for drawing causal inference.

We focused on one of the three greening criteria, the crop diversification measure, as its requirements are formulated at the farm level and differ depending on the farm size and as farm-level compliance can be ascertained from information collected in national surveys.[2] The measure lays out different requirements for three distinct farm size categories. Farms with less than 10 ha of arable land are exempt. Farms with 10 to 30 ha of arable land must grow at least two different crops, and the main crop cannot exceed 75 percent of the farm's total arable land. Farms with more than 30 ha of arable land are required to grow at least three crops, the main crop must not cover more than 75 percent of the farm's arable land, and the two largest crops together cannot cover more than 95 percent of the farm's total arable land. In view of this new policy instrument, backed by significant EU funds, it is reasonable to wonder whether the measure pushed farmers to change their behavior. Indeed, the measure may have suffered from a large windfall effect (European Court of Auditors, 2017) or may even have decreased farmers' intrinsic motivation and thus resulted in less diversified farms (Bénabou & Tirole, 2003). Policy design is a complex field in which policies can backfire (Petrosino *et al.*, 2005). Even if the measure's effect on diversification were positive, it would still be very important to estimate the impact of the policy. Finally, it would be interesting to understand how the farms complied with the measure, what the impact was on the number of crops on the farm, and which crops were increased or decreased as a result of the reform.

To address these points, we used data from before and after the implementation of the crop diversification measure in France. We used panel data on land use collected from a representative sample of French farmers in 2010, 2013, and 2016. We conducted a rich set of preliminary tests that led us to use regression DD (Angrist & Pischke, 2008) with an RD setup, as in Pettersson-Lidbom (2012) and Leonardi & Pica (2013). Our analysis yielded two types of results. First, the regression analysis results show that the additional requirements for farms larger than 30 ha (at least three crops and a maximum of 95 percent of the arable land used for the two main crops) increased the share of farms that meet the crop diversification requirements by 5 percentage points compared to farms smaller than 30 ha. By allocating a smaller share of land to their second-largest crops, farms greater than 30 ha in size adjusted their land use so

[2] Conversely, the maintenance of permanent grassland areas is managed at the regional level, and farm compliance with land allocation to EFAs cannot be deduced from national surveys.

that their two main crops did not occupy more than 95 percent of their total arable land. One in eight farms larger than 30 ha added another crop to their rotation (compared to the farms below 30ha). Second, the graphical analysis results suggest that, following the CAP reform, both farms larger than 30 ha and those smaller than 30 ha increased their compliance with the crop diversification measure: they increased their number of crops and decreased the share of land occupied by the main crop. Nevertheless, the farms larger than 30 ha used the lands previously occupied by the main crop differently than those smaller than 30 ha. Farms smaller than 30 ha substantially increased the amount of land used by their second- and third-largest crops, while farms larger than 30 ha increased the amount of land used by their third- and fourth-largest crops, consistent with the design of the measure.

Section 2 presents the greening measures and the expected impact of the crop diversification requirements, and Section 3 presents the data used in the analysis. Section 4 discusses the potential identification strategies, given our data setting. Section 5 presents the empirical results obtained. We discuss our results in Section 6 and conclude in Section 7.

2 Greening measures and expected impact of crop diversification requirements

Three requirements must be met to obtain greening payments. First, the permanent grassland must be maintained through the combination of two mechanisms. On the one hand, the proportion of permanent grassland in the total utilized agricultural area covered by CAP direct payments must be monitored. If the ratio falls by more than 5 percent from a given reference level, EU member states must require farmers to restore permanent grassland previously converted to other land uses. On the other hand, member states must designate which areas of grassland are the most environmentally sensitive, and the conversion and plowing of such environmentally sensitive permanent grassland areas are prohibited. Second, farmers with more than 15 ha of arable land must devote an equivalent of 5 percent of that land to ecological focus areas (EFAs), whose main objective is to favor biodiversity. Third, more diversified agricultural landscapes are expected to support biodiversity and ecosystem services, including water quality, pest, and disease control and soil quality (Lin, 2011; Thoyer *et al.*, 2014; Beillouin *et al.*, 2021). These crop diversification objectives are the focus of this paper.

As presented in the introduction, crop diversification requirements differ depending on the size of the farm. Furthermore, farms with more than 75 percent of their arable land covered by grasslands or with 75 percent of their arable area cultivated with forage (if the remaining area is less than 30 ha) are not subject to the measure's requirements. The same applies to farms with perennial crops, rice crops, and organic plots. According to Louhichi *et al.* (2017a), approximately 60 percent of French farms are subject to the crop diversification measure.[3]

The crop diversification measure is designed to affect farms larger than 30 ha and farms between 10 and 30 ha differently. Farms larger than 30 ha are expected to decrease the share of land used by the largest and second-largest crops and increase the share of other crops. Farms between 10 and 30 ha are expected to decrease the share of the main crop and increase the share of other crops. We can expect farmers to comply with the measure because monetary incentives are provided, because many farmers already comply with the measure, and because the remaining farmers might want to conform to the descriptive norm (Donati *et al.*, 2015; Le Coent *et al.*, 2021). Nevertheless, economic theory teaches us that incentive tools that attempt to encourage pro-environmental attitudes by increasing extrinsic motivation can backfire by decreasing intrinsic motivation (Bénabou & Tirole, 2003). Thus, even the direction of the measure's impact remains an empirical question. We also sought to determine the magnitude of the impact and identify the crops affected. Several studies have predicted a large windfall effect of the measure (Mahy *et al.*, 2015; European Court of Auditors, 2017), and this also needs to be examined empirically.

3 Data

[3]See also Hart & Menadue (2013) and Hart (2015) for a presentation and discussion of implementation across EU member states.

3.1 Data sources, outcome variables, and sample size

To evaluate the impact of the crop diversification measure, we built a land use database containing data from a representative sample of French farms from the 2010 agricultural census (Ministère de l'Agriculture (SSP), 2010) and two surveys carried out in 2013 and 2016 by the French Ministry of Agriculture (Ministère de l'Agriculture (SSP), 2013, 2016).[4] These three data sources were paired based on a unique identifier for agricultural holdings (the French business identification or 'SIRET' number). Farms less than 10 ha in size were excluded from the analysis, as the samples of farms with less than 10 ha in the 2013 and 2016 surveys were too small and prevented us from exploiting the discontinuity of the crop diversification requirement at the 10-ha threshold. Our original sample included all other eligible farms surveyed at least once in 2016 and in a pre-reform year (2010 or 2013), i.e., a total of 16,182 farms. Nevertheless, for the main analysis, we focused on farms whose arable area was near the threshold of 30 ha (see Section 4).[5]

From the available data, we constructed several indicators to assess the likely impact of the crop diversification measure. We compiled a list of indicators of direct impact of the measure, including: whether or not the farmer complies with the requirements for farms larger than 30 ha (a dummy variable that takes the value of "1" if yes, otherwise "0", regardless of the size of the farm), the number of crops cultivated on the farm, the percentage of the arable area planted with the main crop, the percentage of arable area planted with the second main crop, and the percentage of arable area planted with the two main crops.

It should be mentioned that in some cases, the data available did not allow us to reconstruct the number of crops on the farm accurately. The information related to the cultivation of "fresh vegetables, melon, and strawberries" collected in the surveys is aggregated so that if three different crops (strawberries, zucchini, and cucumber, for example) are grown on the farm, we can only count one. This problem only affects market gardening farms, which represent a limited number of farms. In addition, farms with more than 75 percent of their arable land used

[4]These surveys were led by the National Institute for Economical Statistics (INSEE). Participation was compulsory, and as such, the data are protected by statistical confidentiality and cannot be used for control or sanctions.

[5]The data can be accessed through the secure data hub of the CASD: https://www.casd.eu/en/.

for maize are permitted to plant specific cover crops and count the cover crop as one of the three crops by obtaining certification. We dropped "market gardening" and "maize" farms from the sample in the descriptive statistics and main estimations, as it was impossible to determine with certainty whether farms fulfilled the crop diversification requirements. However, we reintegrated them into the robustness checks to test the sensitivity of the estimates to their presence.[6]

As explained in the next section, in the empirical analysis, we used two main samples: the whole sample and the sample of 20- to 40-ha farms. The table below presents the data availability patterns:

Table 1: Data availability patterns

	Whole sample	20-40 ha bandwidth
Farms surveyed in 2010, 2013 & 2016	4,149	359
Farms surveyed in 2010 & 2016	11,669	1,217
Farms surveyed in 2013 & 2016	364	35
Total no. of farms	16,182	1,611
Total no. of obs	36,513	3,581

Note: The sample included only eligible farms for which we were able to measure compliance with the crop diversification measure precisely.

The sample used for the main results comprised 1,611 farms whose arable land in 2016 was between 20 and 40 ha.

3.2 Descriptive statistics

Table 2 displays the main characteristics of the 2016 outcomes of interest for the sample used in the main estimates, i.e., a subset of the 1,611 farms distributed around the 30-ha threshold with a bandwidth of 10 ha (see the next section). In this table, we also present information on the socioeconomic and geographic characteristics of the farms in the sample. The aforementioned covariates were used in the balancing statistics and robustness tests.

Table 2 indicates that the majority of these farms comply with the crop diversification measure requirements and cultivate, on average, 3.9 different crops. On average, the two main

[6] In the sample of 20- to 40-ha farms used in the main estimations, "market gardening" and "maize" farms represented 8.47 percent of the total number of farms, with "maize" farms accounting for 5.28 percent.

crops occupy 80 percent of the arable area (the largest crop occupies 52 percent of the arable land and the second-largest crop occupies 28 percent of the arable area). Yet, as we will see, these statistics hide a great heterogeneity between farms larger and smaller than 30 ha.

Table 2: Descriptive statistics

	Mean	Sd	Min	Max	N
Outcomes					
Compliance (yes=1)	0.847	0.360	0	1	1,611
Number of crops	3.868	1.148	1	9	1,611
Share of the first crop (%)	52.1	13.7	17.5	100	1,611
Share of the second crop (%)	28	8.8	0	50	1,611
Share of the two main crops (%)	80.1	13.2	33.9	100	1,611
Covariates					
Gender of the head of farm (male=1)	0.805	0.396	0	1	1,611
Birth year of the head of the farm	1963	9.511	1922	1993	1,611
No. of partners	0.714	1.102	0	10	1,611
Workforce on the farm (no. of full time)	2.175	9.230	0.125	308.596	1,611
Irrigable parcels (yes=1)	0.282	0.450	0	1	1,611
Disadvantaged area	0.248	0.432	0	1	1,611
Area with specific disadvantage	0.016	0.124	0	1	1,611
Mountainous area	0.076	0.265	0	1	1,611
Quality label	0.340	0.474	0	1	1,611
Diversification	0.135	0.342	0	1	1,611
Highest diploma: less than high school	0.567	0.496	0	1	1,611
Highest diploma: high school	0.242	0.428	0	1	1,611
Highest diploma: university degree	0.191	0.393	0	1	1,611

Note: Variable values in 2016 are shown. The sample included farms eligible for the crop diversification measure whose area was between 20 and 40 ha. Compliance is a dummy variable with a value of 1 if the farm complies with the crop diversification criteria for farms larger than 30 ha, regardless of the size of the farm.

Approximately 80 percent of farm heads are male, and one-third of the farms are located in areas with some type of natural disadvantage (economically disadvantaged areas, areas with specific disadvantages, or mountainous areas). In addition, approximately one-third of the farms produce at least one product with a quality label, and 13.5 percent practice a diversification activity on the farm (olive oil, milk, leisure activities, etc.). Finally, most farm heads do not possess a high school diploma.

Note that some of the available covariates, such as the number of employees, the quality labels, and the diversified nature of the activity, can be positively correlated with revenue and thus favor the adoption of costly environmental practices such as crop diversification. Some other available covariates, such as the number of farming partners (which indicates whether the farmer makes decisions alone), can complicate the decision-making process and thus the quick adoption of new CAP rules.

4 Empirical strategy and preliminary tests

Given the panel data nature of our sample (from years 2010, 2013, and 2016) and the implementation of the reform in 2015, several methods could be used to study the impact of the crop diversification measure: RDD, DD, or a combination of the two. Preliminary tests detailed below ruled out the suitability of the first two methods.

It should be noted that, as stated in the introduction, for each of the methods used, we compared farms larger than 30 ha to farms smaller than 30 ha. The measure's requirements concerning the main crop are the same (it must not exceed 75 percent of the arable land). Thus, our comparison sheds light on the impact of the two additional rules imposed on farms larger than 30 ha, i.e., that they must grow at least three crops and that their two main crops must occupy less than 95 percent of the total arable land.

4.1 Regression discontinuity design

When units (here, farms) receive a treatment (here, crop diversification constraints) based on whether their value of an observed covariate (here, the arable land area of the farm) is greater or below a known cutoff (here, 30 ha), one potential identification strategy is to use RDD. The idea is that the probability of receiving the treatment conditional on this covariate jumps discontinuously at the cutoff, making the treatment assignment unrelated to potential confounders (Calonico *et al.*, 2014a). Comparing units close to the cutoff (i.e., within a defined bandwidth) makes it possible to create conditions close to those of a randomized control trial. Lee & Lemieux (2010) refer to this as "local randomization."

Consequently, we propose the estimation of the impact of the crop diversification measure using the following equation based on 2016 data:

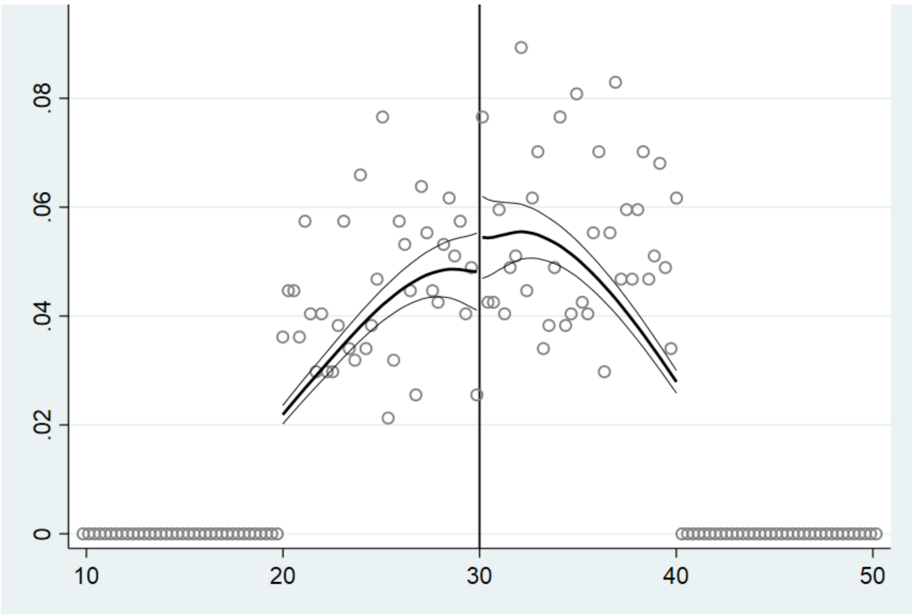
$$Y_i = \alpha + \beta_1 I[arable\_area_i > 30] + \varepsilon_i, \quad (1)$$

where Y_i is one of the outcomes for farm i described in Section 3.1, I[.] is an identity function that takes the value "1" if the farm's arable land area is greater than 30 ha[7], and ε_i is an error term. Equation 1 can be estimated with local estimators, using observations around the bandwidth. The bandwidth can be defined by the researcher, or the optimal bandwidth can be determined using automated selection procedures (see Calonico *et al.*, 2014a). Both possibilities are explored in this paper.

RDD is a valid empirical design if it can reproduce the conditions of local randomization. These conditions must thus be tested. To assess the validity of a RDD estimation, we follow the recommendations of Lee & Lemieux (2010). First, we check for the absence of threshold manipulation. The design would be invalidated if, for instance, all agents just above the threshold that think they will not be able to fulfill the conditions of a new policy manage to get below the threshold. In our case, the risk would be an overestimation of the policy impact. McCrary (2008) proposed a Wald test that we implement here (H0: the discontinuity is zero). The absence of a discontinuity in the density of farms around the cutoff of 30 ha (in 2016) for farms between 20 and 40 ha is not rejected based on the results of the statistical test (test value: 0.122, standard error: 0.106, t-ratio: 1.151), indicating that there is no evidence of manipulation of the threshold, i.e., farmers do not change the size of their farm (by selling or ceasing to rent land) to avoid being subject to the crop diversification criteria that apply to farms larger than 30 ha. A graphical test is shown in Figure 1.

[7] As defined in Section 2.

Figure 1: McCrary threshold manipulation test



(Bandwidth: 10, bin size: 0.282.

Results, available upon request, are qualitatively the same if we use 2013 data in place of 2016 data.)

Second, as for randomized control trials (RCT), covariate values must be balanced between treated and control observations for the design to be valid. Balancing statistics displayed in Table 3 do not reveal that farms larger and smaller than 30 ha (with a 10-ha bandwidth) are different, based on observable pre-treatment characteristics (in 2010). The rule of thumb is that the absolute value of the normalized difference must be below 0.25 (Stuart, 2009) for the two groups to be considered similar.[8]

[8] We used 2010 data for the balancing statistics for two reasons. First, 98 percent of farms in the 2016 sample were also surveyed in 2010, as opposed to only 28 percent in 2013 (see Table 1). Second, as the reform was initially planned for 2014, anticipation of the measure could have influenced the behavior of French farmers. Nevertheless, we checked the sensitivity of our results to the use of 2013 data in place of 2010 data. Note that the same applies for the placebo test (see Table 4).

Table 3: Balancing statistics, 2010 data

	Treated			Control			Normalized
Variables	Mean	Std. Dev.	N	Mean	Std. Dev.	N	differences
Gender of the head of farm (male=1)	0.812	0.391	868	0.808	0.394	708	0.005
Birth year of the head of the farm	1962	8.949	868	1961	9.259	708	0.230
No. of partners	0.720	1.088	868	0.695	1.177	708	0.017
Workforce on the farm (no. of full time)	2.050	6.548	868	2.210	11.052	708	-0.038
Irrigable parcels	0.238	0.426	868	0.291	0.455	708	-0.056
Disadvantaged area	0.228	0.420	868	0.278	0.448	708	-0.054
Area with specific disadvantage	0.018	0.135	868	0.013	0.112	708	0.012
Mountainous area	0.062	0.242	868	0.090	0.287	708	-0.039
Quality label	0.408	0.492	868	0.340	0.474	708	0.069
Diversification	0.106	0.308	868	0.137	0.344	708	-0.038
Highest diploma: less than high school	0.502	0.500	868	0.470	0.499	708	0.032
Highest diploma: high school	0.124	0.330	868	0.106	0.308	708	0.023
Highest diploma: university degree	0.373	0.484	868	0.424	0.494	708	-0.051

Note: Control = from 20 to 30 ha. Treated = from 30 to 40 ha. The normalized difference is the difference in means between the two groups considered divided by the square root of the sum of variances for both groups. The results, available upon request, are qualitatively the same if we use 2013 data in place of 2010 data.

Finally, as balancing statistics did not allow us to check the similarity of many of the farm characteristics (the unobservables), we implemented a falsification test. We ran a RDD on the 2010 data using the 30-ha cutoff as a placebo treatment. The share of the first crop appeared to be affected by the placebo treatment, as shown in Table 4. When we ran a RDD on the 2013 data or used a larger sample (including farms not observed in 2016), we found that most indicators appeared to be affected by the placebo treatment (results available upon request). This means that our two farm groups differ in unobserved characteristics. The validity of a RDD estimator in our context was thus rejected.

Table 4: Impact of the crop diversification measure using a RDD for the 2010 data (placebo test)

Outcome	Coef.	Std. Error	t	Z-value	No. of obs	Bandwidth	Y_1
Compliance (yes=1)	-0.032	0.044	-0.714	0.475	1532	9.861	0.839
Number of crops	0.063	0.151	0.221	0.825	1796	10.968	4.223
Share of the first crop (%)	0.029	0.019	1.724	0.085	1219	7.467	0.515
Share of the second crop (%)	-0.010	0.011	-1.084	0.278	1484	9.049	0.270
Share of the two main crops (%)	0.015	0.016	1.071	0.284	1429	8.777	0.780

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, as estimated by the RDD method using the 2010 data. Robust standard errors are reported in the third column. Y_1 gives the mean values of the outcome in the group of treated farms within the bandwidth. The results, available upon request, are qualitatively the same if we use 2013 data in place of 2010 data.

4.2 Differences-in-differences

Given that we have data for a period prior to the implementation of the measure, another potential strategy is to conduct a DD analysis. This would allow us to control for individual factors that are time-invariant, as well as for common annual shocks. Thus, we estimate the following equation using regression DD with the OLS-FE estimator on data from 2010 to 2016 (Angrist & Pischke, 2008):[9]

$$Y_{it} = \alpha + \beta_1 I[arable\_area_{it} > 30] * Post_{2015} + \gamma_t + \mu_i + \epsilon_i, \tag{2}$$

where $Post_{2015}$ is a dummy variable equal to 1 for years after the CAP reform (the first year of application was 2015), γ_t is a vector of year dummies t, and μ_i a vector of farm dummies.

To check whether regression DD is a valid identification strategy in our case, we need to test for the existence of a parallel trend between the small and large farms prior to the implementation of the reform. To do so, we estimate a fixed-effects model from panel survey data collected in 2010 and 2013. Table 5 displays the results, which indicate that we can reject

[9] When data for more than two periods are available, one can run a regression DD with the OLS-FE estimator instead of a simple DD (see Angrist & Pischke, 2008, Section 5.2.1).

the null hypothesis of no impact for most indicators. This suggests that the parallel trend assumption does not hold when considering the whole sample of farms. The two farm group outcomes evolved differently from 2010 to 2013. This is not surprising, as we are comparing very different farms; farms in the control group are between 10 and 30 ha in size, and some in the treatment group are larger than 200 ha in size.

Table 5: Parallel trends in crop diversification indicators

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms
Compliance (yes=1)	-0.009	0.025	-0.37	0.714	8,298	4,149
Number of crops	-0.124	0.058	-2.14	0.032	8,298	4,149
Share of the first crop (%)	0.018	0.010	1.92	0.055	8,298	4,149
Share of the second crop (%)	-0.017	0.008	-2.19	0.029	8,298	4,149
Share of the two main crops (%)	0.001	0.006	0.19	0.847	8,298	4,149

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the difference-in-difference method over the pre-reform period. Robust standard errors are reported in the third column. The results, available upon request, are qualitatively the same if we control for the covariates listed in Table 3.

4.3 Combining DD and RD setup

As shown in the previous subsections, we could not apply a RDD, because units around the cutoff are not directly comparable in years prior to the reform, nor can we use a DD design, because large and small farms were on differential land use trends before the program began. We thus exploited two sources of variation, before/after 2015 and larger/smaller than 30 ha, and we used a regression DD combined with a regression discontinuity setup, as in Pettersson-Lidbom (2012) and Leonardi & Pica (2013), to identify the effects of the reform. This consisted of applying the OLS-FE estimator to the subset of farms around the threshold.[10]

[10] An alternative strategy would have been to use a difference-in-discontinuity design, as in Grembi *et al.* (2016), but their estimator does not include individual fixed effects, which is essential here to control for unobservable characteristics, and for many farms, we wanted to use not one but two pre-treatment periods (2010 and 2013) to improve identification. The difference-in-discontinuity estimator derived by Grembi et al. implies the need to construct several interacting variables to obtain consistent estimates. Grembi et al. did not derive the estimator to use when individual fixed effects are included in the regression, and it is not the ambition of this paper to do so.

Formally, we estimated Equation 2 based on observations within a bandwidth determined using the mean-squared-error optimal bandwidth selector (Calonico *et al.*, 2014b). The bandwidths differ depending on the outcome of interest and the year considered, which can make results complicated to analyze since the sample of farms is different for every regression. As all automated selected bandwidths in the main estimates were around 10, we fixed the bandwidth to 10 in most of our analyses but checked the robustness of our results to the use of bandwidths of 8 and 12, as well as automated selected bandwidths.[11]

A validity assumption for our empirical strategy was the existence of parallel trends between small and large farms before the reform began. To do so, we estimated a fixed-effects model from panel survey data collected in 2010 and 2013, with a placebo treatment in 2013. Table 6 displays the results. In all cases, we could not reject the null hypothesis of no impact, which supports the parallel trend assumption for the subset of farms around the cutoff. Note that the absence of threshold manipulation is also a condition for the validity of this estimator. As previously shown in Figure 1, threshold manipulation does not seem to be an issue in our sample.

Table 6: Parallel trends in crop diversification indicators with a bandwidth $= 10$

Outcome	Coef	Std. Error	t	P-value	No. of obs	No. of farms	Y_1
Compliance (yes=1)	-0.006	0.044	-0.14	0.886	718	359	0.747
Number of crops	-0.135	0.104	-1.3	0.195	718	359	3.856
Share of the first crop (%)	-0.008	0.015	-0.54	0.589	718	359	0.549
Share of the second crop (%)	0.008	0.011	0.76	0.445	718	359	0.268
Share of the two main crops (%)	0.000	0.011	0.04	0.968	718	359	0.817

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by OLS-FE over the pre-reform period. Robust standard errors are reported in the third column. The results hold when we use automatically selected bandwidths (see Table A.1).

[11] We do not claim that the bandwidth used here is optimal and unbiased. We chose to compute the optimal bandwidth suitable for cross-sectional RDD to serve as formal guidance and limit arbitrary choices from our side. Furthermore, note that the advice of Lee & Lemieux (2010) is to not rely particularly on a method or bandwidth but rather, as with any empirical analysis, to check that the results are stable across alternatives. That is the philosophy we sought to adopt here, as in Pettersson-Lidbom (2012). Finally, note that the empirical strategy described in this section ultimately relies on the farm fixed effects and the existence of parallel trends, an assumption that was tested, as shown in Table 6.

Thus, we analyzed the impact of the crop diversification measure of the CAP greening reform by combining regression DD with an RD setup.

5 Results

5.1 Main results

The results of our OLS-FE estimations on farms around the bandwidth are displayed in Table 7.

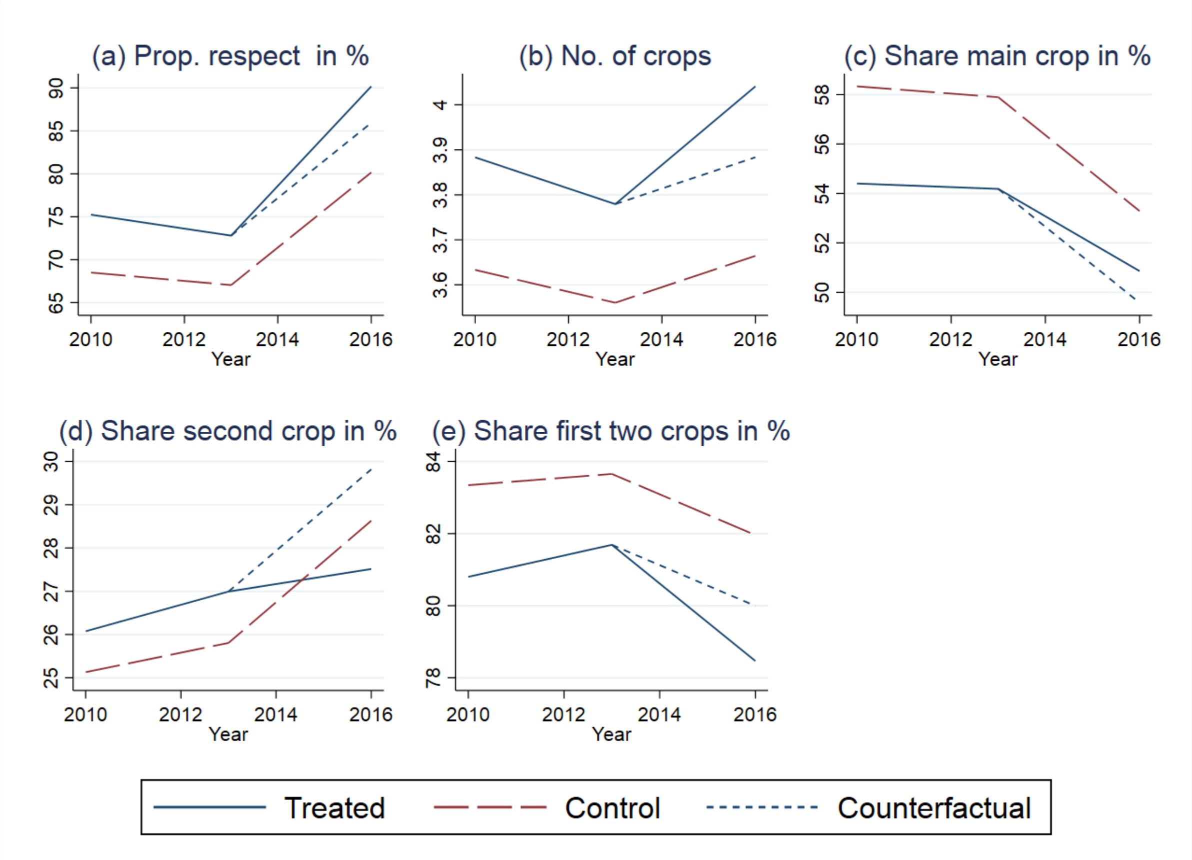
Table 7: Impact of the crop diversification measure on the subset of 20- to 40-ha farms

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Y_1
Compliance (yes=1)	0.051	0.023	2.2	0.028	3,581	1,611	0.896
Number of crops	0.110	0.060	1.84	0.066	3,581	1,611	4.033
Share of the first crop (%)	0.006	0.008	0.74	0.461	3,581	1,611	0.510
Share of the second crop (%)	-0.019	0.005	-3.55	0.000	3,581	1,611	0.276
Share of the two main crops (%)	-0.013	0.006	-2.19	0.029	3,581	1,611	0.786

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, as estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth. The results, available upon request, are qualitatively the same if we control for the covariates listed in Table 3 or cluster standard errors at the regional level. The results also hold when we use automatically selected bandwidths (see Table A.2).

As we can see, the measure increased by 5 percentage points the share of farms larger than 30 ha that meet the crop diversification conditions, compared to the farms under 30 ha. The results show a significant difference between the two groups in the number of crops cultivated ($+0.12$), suggesting that the measure made it possible for more than one in eight farms to add a crop. As expected, the results do not show an effect on the percentage of land used by the main crop (as the requirement concerning the main crop is the same for farms larger and smaller than 30 ha). The estimates, however, indicate that on farms larger than 30 ha, the share of land used for the second-largest crop decreased by 2 percentage points more than on farms under 30 ha. While these results are interesting, it is plotting the average value of the outcomes over time that helps us to understand the mechanisms at play.

Figure 2: Main results



First, the existence of parallel trends from 2010 to 2013 shown in Table 6 can clearly be seen in Figure 2. Figure 2.c and the regression results in Table 7 show that, as expected, farmers in both groups reacted in the same way to the rule dictating the surface area to be used for the main crop. The curves suggest that both groups decreased the percentage of land used for their main crop. Figure 2.d reveals part of the mechanism at play here. We see that farms under 30 ha appear to have increased the land area used for the second crop by 3.5 percent as a response to the decrease in the allowable percentage of surface area used for the main crop, while farms larger than 30 ha increase it by only 1.5 percent. This finding is consistent with the fact that farms larger than 30 ha also face a constraint on the share of their land that can be used by their two largest crops.

To understand how both groups of farms responded to the measure, it is useful to run the analysis for other crops. Table 8 presents the regression results, while the average value of the outcomes over time are plotted in Figure 3.[12] We focused on the third-, fourth-, and fifth-

[12]A test for the existence of parallel trends for these alternative outcomes is presented in Table A.3.

largest crops, as fewer than 10 percent of farms have more than five crops (fewer than 1 percent have eight or more crops).[13]

Table 8: Impact of the crop diversification measure on additional crops of 20- to 40-ha farms

Outcome	Coef	Std. Error	t	P-value	No. of obs	No. of farms	Y_1
Share of the third crop (%)	0.004	0.004	1.03	0.305	3,581	1,611	0.139
Share of the fourth crop (%)	0.009	0.003	3.18	0.001	3,581	1,611	0.055
Share of the fifth crop (%)	0.001	0.001	0.6	0.547	3,581	1,611	0.016

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure as estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Figure 3: Secondary results

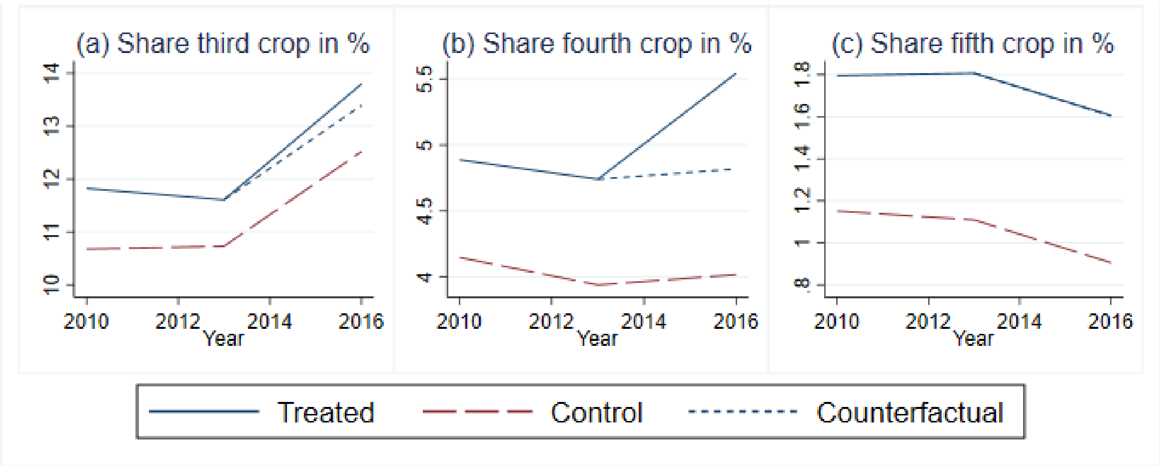


Figure 3.a suggests that both groups increased the area used for their third-largest crop (the difference in increase between the two groups was not significant). Figure 3.b suggests that the treated group increased the surface area occupied by the fourth-largest crop significantly more than the control group did. For the fifth-largest crop, we did not observe a significant difference between the two groups (see Table 8).

In summary, the additional rules for farms larger than 30 ha affected farmers' behavior,

[13]The low number of concerned farms makes crops 6 to 8 less relevant to assessing the impact of the policy and could require specific treatment for zero-values, which would not be straightforward, especially because we are not dealing with whole numbers (count data). Nevertheless, the results for the impact of the crop diversification measures for crops 6 to 8 are available upon request. We found no impact of the crop diversification measure on these crops. The existence of parallel trends was also not rejected for these crops.

increasing their compliance with the measure and the number of crops grown. Furthermore, the graphical analysis, while not causal (as we do not have a pure control group completely unaffected by the reform), is informative. It suggests that both groups increased their compliance with the legislation and decreased the share of land occupied by the main crop, although the groups responded differently in terms of the crop they chose to increase to comply with the legislation.

5.2 Robustness checks

We used three methods to test the robustness of the main estimates.

First, we varied the bandwidth to verify that the main results still held even when the window was slightly increased or decreased. This is a way of verifying that the results are not driven by observations at the edge of the window. Table A.4 displays the results for the estimates from the subset of the 1,300 farms distributed around the 30-ha threshold, the size of which varied between 22 and 38 ha (bandwidth $= 8$). Table A.5 displays the results for the estimates for the subset of the 1,936 farms distributed around the 30-ha threshold, the size of which varied between 18 and 42 ha (bandwidth $= 12$). The results hold.

Second, we re-estimated the model but kept in the same sample farms that do market gardening or have corn as a main crop. Table A.6 displays the results, which are similar to the main results.

Third, we applied a final falsification test. To define the treated and control groups, we used thresholds for which there should be no treatment effect. Table A.7 displays the results obtained when 25 ha was used as a threshold, Table A.8 displays the results obtained when 40 ha was used as a threshold, and Table A.9 displays the results obtained when 100 ha was used as a threshold. Again a bandwidth of 10 was used, apart from the 25-ha threshold, for which a maximum bandwidth of 5 ha was used to avoid having a mix of treated and untreated farms on each side of the bandwidth. In all cases, we could not reject the null hypothesis of no impact, which supports the validity of our identification strategy and main results.

6 Discussion

Previous ex post studies, such as Bertoni *et al.* (2018, 2021), have highlighted a strong effect of the crop diversification measure in regions with high-intensity agriculture, whereas Díaz-Poblete *et al.* (2021) claim that the CAP greening reform had a limited impact. The most comprehensive ex ante study on the CAP greening reform, Louhichi *et al.* (2015, 2017b), predicted that 3.8 percent of eligible farms in France would increase compliance as a result of the crop diversification measure to reach an overall 96.3 percent (full) compliance rate and that another 3.5 percent would increase compliance compared to the baseline without fully complying with the crop diversification requirements. We found that compliance of farms larger than 30 ha increased by 5 percentage points more than that of farms smaller than 30 ha, but the graphical analysis showed that compliance increased substantially in both groups. Our results are globally consistent but not directly comparable to those of the aforementioned studies. Those studies focused on all farms in the Lombardy region of Italy (Bertoni *et al.*, 2018, 2021), all farms in Spain (Díaz-Poblete *et al.*, 2021), and a representative sample of all farms in France (and even Europe, Louhichi *et al.*, 2015, 2017b), whereas we focused on 20- to 40-ha French farms. Our contribution is to provide results using a causal identification strategy at the cost of providing a local average treatment effect (LATE). We discuss the out-of-sample validity of our results next.

By its nature, the use of a discontinuity in treatment design provides the researcher with a LATE. Examining the percentage of farms from 10 to 110 ha in size that comply with the crop diversification requirements for farms larger than 30 ha helped us to assess the out-of-sample validity and interest of our results.

Figure 4: Compliance with the crop diversification measure

(Source: the authors, based on the land use of 16,182 farms from 10 to 110 ha in size. Compliance is reflected by a dummy variable with a value of 1 if the farm complies with the crop diversification criteria for farms larger than 30 ha, regardless of the size of the farm.)

As we can see in Figure 4, the percentage of farms complying with the requirements for farms larger than 30 ha was not significantly different between 2010 and 2013 but increased significantly in 2016. Compliance increases with the size of the farm, with an estimated average compliance of 97 percent by farms of 100- to 110-ha in size. This may appear logical as, for instance, it is easier to have at least three crops on 80 ha than on 10 ha. An initial observation is that the windfall effect of the measure probably increases with farm size but that compliance has increased from 2013 to 2016. A second observation is that the gap between 2010-2013 and 2016 is at its maximum for 30- to 40-ha farms (from 72 to 88 percent compliance). This second observation is consistent with our findings. The additional measures for farms larger than 30 ha had an impact on farmers' choices, and we were able to capture and measure this additional increase in diversification with our empirical strategy. This also suggests that farms of 30- to 40-ha in size were the ones that had to make the greatest changes. We can assume that if a similar measure had been implemented at a larger threshold, such as, for instance, 40 ha, we would probably have observed lower impacts, and the measure would have been less useful (larger windfall effect and fewer farms changing their land use). With regard to the out-of-the-country validity, Louhichi *et al.* (2017a) 's simulation results indicate that land reallocation due to the greening reform was expected to be greater in two-thirds of the EU-27 countries than in France. This might be similar in our case, as our measured impact could be lower in terms of average impact at the European level. Broader insights would require the application of a methodology similar to ours to data on other EU countries.

To summarize this discussion, the crop diversification measure worked in the expected direction. The number of crops increased in the treated groups, and the share of the first two crops in total land use decreased. This result is not trivial, as we know that policy design is a complex field in which outcomes are sometimes the opposite of policy goals. A well-known example of this phenomenon is the "Scared Straight" program in the US (Petrosino *et al.*, 2005), which organized visits to prisons by juvenile delinquents in an attempt to deter them from criminal activity but actually increased delinquency and thus did more damage than if nothing at all had been done. Bénabou & Tirole (2003)'s contribution highlighting the fact that extrinsic motivation can decrease intrinsic motivation is another famous illustration. The first contribution of our study is to show that this phenomenon did not occur in the case of the crop diversification measure. Our results are important from a policy perspective, as we evaluate a measure linked to a substantial share of the CAP budget and provide an estimate of the magnitude of the changes brought about by the crop diversification policy. Our empirical analysis results suggest that the two groups of farms, those greater than 30 ha in size and those smaller, decreased the share of land used by their main crop but responded differently in terms of the crop they chose to increase to comply with the legislation. For the farms larger than 30 ha in size, we observed an increase in the share of farmland used for the third- and fourth-largest crops, while in the farms less than 30 ha in size, we observed an increase in the share of farmland occupied by the second- and third-largest crops. Although we can identify no theoretical mechanism that explains why these specific crops increased, the increases are plausible, given the design of the crop diversification measure. To the best of our knowledge, the fact that these specific crops were affected by the measure was not anticipated by ex ante works on the subject.

7 Conclusion

We estimated the impact of the crop diversification measure of the 2013 CAP greening reform in the context of French farms. We used regression DD combined with an RD setup, and we used a set of placebo and falsification tests to select the best approach and evaluate its validity.

We found that the additional requirements for farms larger than 30 ha increased farmers' compliance with the measure and the number of crops grown. Furthermore, the graphical analysis suggests that both farm groups (farms larger and smaller than 30 ha) increased their compliance with the legislation and decreased the share of land used for their main crop but that the groups responded differently in terms of the crop they chose to increase to comply with the legislation. For the group of farms larger than 30 ha, we observed an increase in the share of the farmland used for the third- and fourth-largest crops, while for the group of farms under 30 ha, we observed an increase in the share of farmland occupied by the second- and third-largest crops. Thus, the measure changed the behavior of farmers in the expected ways, although economic theory and the history of public policy evaluation teach us that this was not a foregone conclusion. Nevertheless, the fact that the two groups of farms responded to the measure by increasing different crops was not anticipated by ex ante works on the subject and highlights the importance of analyses of ex post data such as the one we present in this paper.

Our results are valid for farms approximately 30 ha in size. Indeed, discontinuity designs produce LATE. We suspect the magnitude of the effects decreases along with farm size. If we put our results into perspective regarding the findings of ex ante studies, the impact of the measure could be greater for approximately two-thirds of EU countries. Furthermore, in the case of France, a large number of the farms were already complying with the diversification requirements. Consequently, tailored measures both between and within countries might be an appropriate way to increase additionality.

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Appendices

Table A.1: Parallel trends in crop diversification indicators with an automated selected bandwidth

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Bandwidth	Y_1
Compliance (yes=1)	-0.007	0.046	-0.16	0.872	674	337	9.175	0.747
Number of crops	-0.120	0.108	-1.11	0.268	674	337	9.176	3.839
Share of the first crop (%)	-0.007	0.014	-0.48	0.632	674	337	11.109	0.543
Share of the second crop (%)	0.003	0.010	0.33	0.743	674	337	13.155	0.266
Share of the two main crops (%)	0.001	0.011	0.06	0.956	674	337	10.470	0.814

Note: : The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the OLS-FE method on data around an automated selected bandwidth over the pre-reform period. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Table A.2: Impact of the crop diversification measure (automated selected bandwidth)

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Bandwidth	Y_1
Compliance (yes=1)	0.041	0.024	1.71	0.088	3,280	1,470	8.972	0.896
Number of crops	0.103	0.063	1.63	0.104	3,265	1,464	8.900	4.057
Share of the first crop (%)	0.007	0.008	0.91	0.362	3,929	1,767	10.706	0.511
Share of the second crop (%)	-0.021	0.005	-4.4	0	5,109	2,308	13.844	0.277
Share of the two main crops (%)	-0.015	0.006	-2.38	0.017	3,525	1,582	9.566	0.785

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the OLS-FE method on data around an automated selected bandwidth. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Table A.3: Parallel trends in crop diversification indicators (other crops) on the subset of 20-40 ha farms

Outcome	Coef	Std. Error	t	P-value	No. of obs	No. of farms	Y_1
Share of the third crop (%)	0.002	0.008	0.29	0.774	718	359	0.114
Share of the fourth crop (%)	-0.002	0.005	-0.42	0.676	718	359	0.047
Share of the fifth crop (%)	0.002	0.003	0.66	0.508	718	359	0.017

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the difference-in-discontinuity method, over the pre-reform period. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth, which is determined using an automatic procedure.

Table A.4: Impact of the crop diversification measure on the subset of 22-38 ha farms

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Y_1
Compliance (yes=1)	0.039	0.026	1.50	0.135	2,893	1,300	0.891
Number of crops	0.124	0.067	1.85	0.065	2,893	1,300	4.034
Share of the first crop (%)	0.002	0.009	0.26	0.791	2,893	1,300	0.509
Share of the second crop (%)	-0.019	0.006	-3.11	0.002	2,893	1,300	0.276
Share of the two main crops (%)	-0.016	0.007	-2.38	0.017	2,893	1,300	0.785

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Table A.5: Impact of the crop diversification measure on the subset of 18-42 ha farms

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Y_1
Compliance (yes=1)	0.049	0.021	2.32	0.021	4,289	1,936	0.905
Number of crops	0.100	0.055	1.82	0.069	4,289	1,936	4.059
Share of the first crop (%)	0.010	0.007	1.35	0.178	4,289	1,936	0.508
Share of the second crop (%)	-0.021	0.005	-4.13	0	4,289	1,936	0.276
Share of the two main crops (%)	-0.011	0.006	-1.97	0.049	4,289	1,936	0.784

Note: The values in the column labeled “Coef.” reflect the impact of the crop diversification measure, estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Table A.6: Impact of the crop diversification measure including farms that do market gardening and grow corn as their main crop

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Bandwidth	Y_1
Compliance (yes=1)	0.055	0.022	2.49	0.013	3,917	1,760	10	0.858
Number of crops	0.138	0.057	2.42	0.016	3,917	1,760	10	3.979
Share of the first crop	0.002	0.007	0.27	0.785	3,917	1,760	10	0.525
Share of the second crop	-0.018	0.005	-3.43	0.001	3,917	1,760	10	0.268
Share of the two main crops	-0.016	0.006	-2.68	0.007	3,917	1,760	10	0.794

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Table A.7: Falsification test with a 25 ha threshold and 5 ha bandwidth

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Y_1
Compliance (yes=1)	-0.068	0.180	-0.38	0.707	1,634	734	0.444
Number of crops	-0.327	0.404	-0.81	0.419	1,634	734	2.333
Share of the first crop (%)	-0.010	0.073	-0.14	0.887	1,634	734	0.641
Share of the second crop (%)	0.044	0.043	1.02	0.308	1,634	734	0.302
Share of the two main crops (%)	0.034	0.036	0.95	0.343	1,634	734	0.943

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Table A.8: Impact of the crop diversification measure on the subset of farms around the threshold of 40 ha

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Bandwidth	Y_1
Compliance (yes=1)	0.000	0.020	0.01	0.995	4,157	1,871	10	0.916
Number of crops	0.001	0.056	0.02	0.987	4,157	1,871	10	4.188
Share of the first crop	-0.001	0.006	-0.18	0.859	4,157	1,871	10	0.501
Share of the second crop	0.002	0.004	0.47	0.638	4,157	1,871	10	0.274
Share of the two main crops	0.001	0.006	0.16	0.873	4,157	1,871	10	0.775

Note: The values in the column labeled “Coef.” reflect the impact of the crop diversification measure, estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.

Table A.9: Impact of the crop diversification measure on the subset of farms around the 100 ha threshold

Outcome	Coef.	Std. Error	t	P-value	No. of obs	No. of farms	Bandwidth	Y_1
Compliance (yes=1)	-0.003	0.012	-0.24	0.813	4,160	1,853	10	0.983
Number of crops	0.074	0.058	1.26	0.207	4,160	1,853	10	5.042
Share of the first crop	-0.001	0.004	-0.26	0.795	4,160	1,853	10	0.477
Share of the second crop	-0.002	0.003	-0.71	0.478	4,160	1,853	10	0.246
Share of the two main crops	-0.003	0.004	-0.78	0.438	4,160	1,853	10	0.723

Note: The values in the column labeled "Coef." reflect the impact of the crop diversification measure, estimated by the OLS-FE method. Robust standard errors are reported in the third column. Y_1 gives the mean value of the outcome in the group of treated farms that are within the bandwidth.