Analysis of the impact of the protection of whole catchments on the local dynamism of the development of organic farming

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Abstract

Since 2009, in response to water pollution problems in France, a policy to Protect Whole catchments (PWC) has been implemented with the aim of preserving and decontaminating these water reserves and preventing them from being abandoned. One of the highlighted actions is the development of organic farming, an agricultural practice that excludes the use of chemical fertilizers and pesticides. This study aims to determine whether this policy effectively contributes to the development of organic agriculture in France.

This study focuses on the 1215 PWC currently defined in France. Two levels of analysis are employed here, at the PWC level and at the individual level (change in farmer behavior). The recent econometric advancements in Difference-in-differences with multiple time periods (Callaway and Sant'Anna, 2021) indicate that this policy may counterintuitively slow down the development of organic farming compared to neighboring untreated areas.

The analysis, involving over 350 000 farmers in France (French LPIS database 2016-2021), allows us to observe changes in agricultural behavior following the use of a portion of these lands within a PWC. The modeling, based on Stammann et al. (2016) (logistic with individual effects), reveals patterns of *leaders* and *free riders*. Indeed, farmers with a significant portion of their lands in PWC, or where these lands are in the majority, are encouraged to make environmental efforts. Conversely, in PWC of significant size, the influence of each farmer is diluted, pushing them toward *free rider* behaviors.

Keywords: `Keyword: Water quality, Organic farming, Whole catchment, DiD dynamic`

Draft – Work in Progress PLEASE DO NOT CITE

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1. Introduction

Agriculture in France accounts for 57% of the total water consumption (average between 2010 and 2018), while only contributing 1.6% to the national economy. In addition to the pressure it places on water resources, agriculture is also a major contributor to water pollution, primarily due to the application of synthetic fertilizers and pesticides, which impact the quality of groundwater (Lerner and Harris, 2009). Indeed, 90% of monitored water sources in France contain at least one pesticide Kristensen et al. (2018). Agriculture thus plays a unique role in relation to water, as a significant consumer and polluter, influencing both the quantity and quality of this resource.

As a result, according to Feuillet and Michon (2016), between 1997 and 2013, 7 716 water catchments were abandoned in France. The main reason for abandonment, for 39% of these water intakes, is pollution. In these intakes, water quality measurements exceed the drinking water standards set by the French Ministry of Health (pesticide concentrations in excess of $0.10\mu g/L$ and nitrates in excess of 50mg/L). The combination of these elements leads to conflicts surrounding the allocation of water resources, as exemplified by the *Méga-Bassine de St Solline* controversy[2].

To address the challenges of water sharing and pollution at the European and national levels, directives have been put in place. The Water Framework Directive (2000/60/EC) is aimed at sharing water resources, while the Nitrates Directives (1991 and 2010-2016) aim to limit water pollution. As part of the Water Framework Directive and the French Environment Code, a list of 500 priority whole catchments was established during the Grenelle Environment Summit in 2009. The river basin management plan for the period 2016-2021 (*Schéma Directeur d'Aménagement et de Gestion de l'Eau* or SDAGE) sets the target of adding another 500 whole catchments. In these areas, the aim is to preserve and restore polluted water reserves, rather than abandoning these catchments.

Thus, out of approximately 33,000 water catchments in France, more than 1,000 are designated for which a steering committee composed of various stakeholders (project owners, funders, government services, representatives of sectors causing pressure, and environmental associations) must engage to decide on actions to be implemented in the area to achieve water preservation objectives.

As shown in the article Barataud et al. (2014), which studied the prioritization of water catchment during the first *Grenelle Environment Summit*, the pollution criterion is a necessary condition for designation, but it also depends on the strategic nature of the intake. In other words, the strategic nature refers to the possibility of substituting the identified water reserve with another water reserve. If the intake is closed, will the population have easy access to another water resource? Finally, a political criterion is a more homogeneous distribution among the departments to avoid negative stigmatization of a particular area.

In this article, we will use Spatial RDD methods Keele and Titiunik (2015), Lee and Lemieux (2010),

[2]This conflict arose between environmental activists and a group of 450 farmers who proposed the creation of 16 reservoirs with a total volume of 6 million m^3 of water, intended for agricultural use. The activists criticized the project for potentially monopolizing water resources for agricultural activity.

which involve exploiting the geographical boundary of an area to designate treated and control individuals. Therefore, in this case, we will use the official boundaries of priority catchment areas as the boundary. Indeed, outside of this zone, farmers cannot benefit from actions related to the policy of PWC. The various choices of the maximum distance for control individuals (from 1 km to 10 km from the catchment area boundary) will allow us to create treated and control groups that are homogeneous in terms of local characteristics.

In this article, our objective is to examine whether the designation of Priority Whole Catchments promotes the growth of organic farming within these regions. We will explore how the proportion of agricultural land within PWC may influence the probability of conversion to organic farming. This paper does not directly analyze the impact of the PWC program, as we will not be looking at improvements in water quality. Rather, we will be looking to see whether this policy has generated unanticipated but expected effects: the conversion of farmers to organic farming.

In this article, we will adopt two levels of analysis. First, the reference level will be the whole catchment, allowing us to observe the impact of the PWC policy on the share of organic farming in this area, in comparison to neighboring similar areas (within 1 to 10 kilometers around). Then, we will shift our level of analysis to the individual farmers. In this section, we will compare the farming practices of farmers affected by the PWC policy with those of other nearby but untreated farmers. The intensity of treatment will be approximated by two indicators: *Weight in the PWC* and *Commitment* The *Weight in the PWC* indicator measures the significance of a farmer's agriculture within a specified PWC in relation to the overall agriculture in the area. This indicator is calculated as the farmer's land area divided by the total land area within the PWC. The second indicator, *Commitment*, measures to what extent this policy affects their operation. This indicator is equivalent to the proportion of the farmer's land area located within an PWC.

2. Literature Review

2.1. Priority Whole Catchment: from delimitation to action plan

The whole catchment designates the zone in which any falling drops may end up in the water reserve. This type of protection zone is added to those already existing in France, namely the "Immediate Protection Zone" and the "Close Protection Zone." These two zones are located around the water extraction point. In the Immediate Protection Zone (a few meters around the extraction facility), no economic activities are allowed to prevent contamination. In the Close Protection Zone (a few hectares around the facility), economic activities are regulated. The Whole Catchment is much larger than these zones because it covers the entire extent of the water reservoir, not just the extraction area (ranging from 50 ha to 150,000 ha compared to just a few hectares for the Immediate and Close Protection Zones). Since the impact of activities in the PWC on water quality is less direct than that of the closer zones, the measures taken in the PWC are more flexible than those in the Immediate and Close Protection Zones. The idea behind the PWC policy is to use different incentive instruments to encourage changes in farming practices, rather than constrain them.

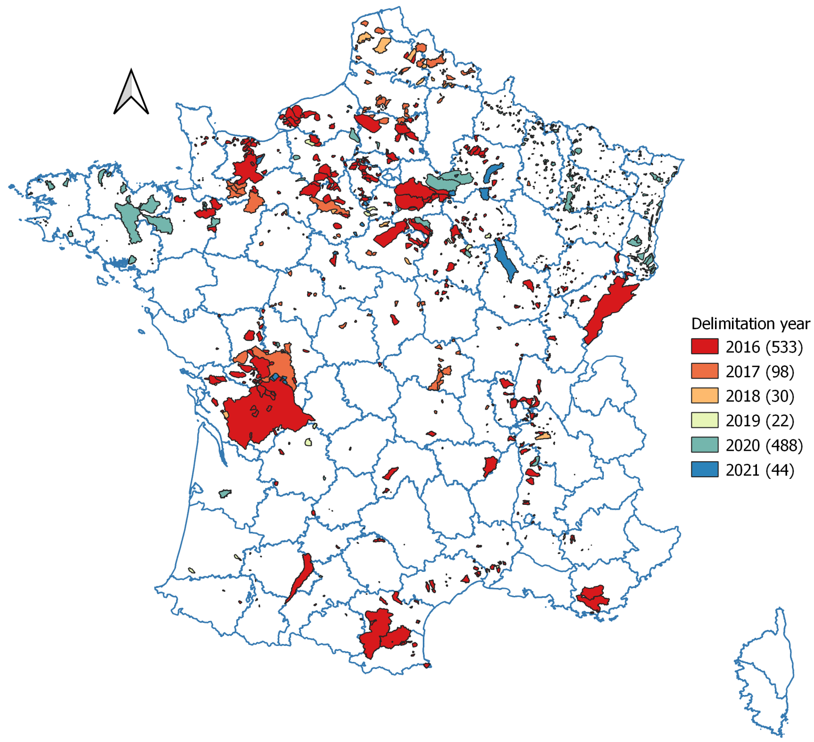

Figure 1: Distribution of capture zones according to the year of delimitation

Once a whole cachment has been identified as a priority, a multi-stage process is set, involving various local players from different institutions. The aim is not to force change, but to encourage voluntary action (with the possibility of monetary incentives). These stakeholders include the project owner, funding bodies (such as the Agence de l'Eau and local authorities), representatives of activities throughout the whole cacthment (such as farmers, industry and transport), environmental associations and water consumers. This co-construction process ensures that the actions developed are more acceptable and appropriate for all parties concerned.

In more detail, the first step in this process, once the catchment to be protected has been identified, involves conducting studies to delimit the whole catchment according to the methodology outlined in Vernoux et al. (2014). As shown in Figure 1, the time between identifying the capture as a priority and officially delimiting the PWC varies greatly from one area to another. Indeed, we observe that every year, new whole catchments are delimited.

Once the area has been delimited, a territorial diagnosis is conducted to identify the various pressures exerted on the water catchments (such as agricultural activities, land use planning, and other activities), as well as an assessment of the water reserve's current state (quality, quantity, and actions already taken). This diagnosis should allow for the identification of both environmental and socio-economic challenges that may be impacted by the implementation of actions aimed at preserving the capture.

Then, the different actors work on designing an action plan that can be accepted by stakeholders and achieve the objectives of preserving the catchment areas. These actions are diverse and can be based on existing regulations, subsidies co-financed by the FEADER fund, the State, and local authorities, such as agri-environmental scheme(AES).

We can focus, on on a type of incentive that is put in place in certain whole cachements: The localized AES. Created in 2007, AES aims to support farmers in agroecological projects. The localized AES are intended for farmers located in areas with specific issues (water issues with PWC, biodiversity issues with Natura 2000 areas). These areas are defined according to the Rural Development Programs of the regions. In catchment areas, the establishment of AES *GRASS* or *PHYTO* is favored, with the respective objectives of preserving and increasing grasslands, and reducing the use of pesticides and chemical fertilizers. Thus, conventional farmers located in PWC have the possibility of receiving aid ranging from €90 to €500/ha (depending on the effort required and the type of crop involved). Organic farmers operating in PWC can receive conversion aid (CAB) or maintenance aid for organic farming[3] (MAB), but cannot combine PHYTO AES and some GRASS AES[4]. Indeed, these aids compensate for the positive environmental externalities of agriculture that are not taken into account by the market. However, since the externalities of organic farming are already compensated by CAB and MAB AES, organic farmers located in PWC cannot enter into contracts for PHYTO or GRASS AES. Since the amounts of subsidies for PHYTO and MAB AES are similar, while the environmental effort required to comply with the organic specifications is greater than that required to achieve the PHYTO objectives, a farmer will be tempted to make the least environmental effort and therefore continue conventional practices to receive the localized AES implemented in PWC.

The analysis will therefore aim to observe whether the monetary instruments implemented in PWC do not have a disincentive effect on environmental effort. If the establishment of localized AES in PWC does not create a windfall effect, which reinforces conventional farmers in their practices and encourages organic farmers to abandon organic farming. (ANALYSIS NOT YET PRESENTED IN ARTICLE)

2.2. Development of organic farming as a solution for improving water quality

Now that the policy has been presented, here is the output observed to judge the effectiveness of the policy.

The use of organic agriculture as a solution for preserving water catchments has been suggested by Barrez et al. (2012), who argues that its implementation can improve water quality. Organic farming prohibits the use of pesticides and synthetic fertilizers, reducing the risk of pollution by nitrates. Permanent soil cover, the use of organic fertilizers Drinkwater et al. (1998), and a greater proportion of pasture allow for a reduction nitrate leaching. According to Mondelaers et al. (2009), after a study conducted in 12 countries, it appears

[3]The availability of maintenance aid for organic farming, under the 2015-2022 CAP programming, varies depending on the regions. Depending on the available budget, regions target specific farmers to prioritize. The Grand Est region, for example, has decided to maintain MAB for organic farmers located in PWC.

[4]GRASS AES 03: Total absence of mineral and organic nitrogen fertilization

that organic farming, compared to conventional practices, reduces nitrate leaching by 9 to 21 kg/ha. However, these same studies show that when normalized by production unit, the difference becomes statistically non-significant. The study by Benoit et al. (2014) found that in large-scale agriculture, even when normalized by production unit, nitrate leaching is lower in organic farming compared to conventional methods.

Munich, since 1992, the city has offered farmers wishing to convert to organic farming subsidies (around 250€ /ha/year) in addition to CAP aid. This policy has enabled the number of organic farmers in the Munich catchment area to rise from 23 in 1993 to 150 in 2010 (86% of the whole cachments agricultural area). This change to organic farming has improved water quality, reducing nitrate levels from 40mg/l in 1980 to an average of 10mg/l today (Barataud et al., 2013).

2.3. Determinants of conversion and continuation in organic farming: Monetary and non-monetary incentives

According to the literature, the decision to convert to organic farming is influenced by a set of variables specific to the farmer, such as age, education (Koesling et al., 2008), farm characteristics (land area, crop type), or geographic characteristics such as the density of existing organic farmers, the presence of downstream organic markets, or proximity to a large number of consumers (Allaire et al., 2014, Nguyen-Van et al., 2021). In contrast, studies on the determinants of remaining organic farming practices are less numerous. However, the current decrease in organic consumption in France (-1.3% between 2020 and 2021 according to Agence Bio (2022)) highlights the importance of preventing future deconversions resulting from market conditions.

Beyond individual characteristics, monetary and non-monetary policies can also encourage organic practices. The studies by Glowacki and von Rueden (2015) and Limbach and Rozan (2022) suggest that when local environmental objectives are identified, the level of environmental effort provided by farmers depends on different factors. Specifically, Limbach and Rozan (2022) finds that farmers who are considered leaders, in terms of having the most land in priority areas, are more likely to provide environmental efforts. This leadership role makes the farmer more willing to produce environmental efforts. Conversely, the more farmers there are in a priority area, the more likely a farmer will exhibit free-rider behavior and rely on others to provide environmental effort.

For the study of PWCs, Durpoix and Barataud (2014), calculates two indicators based on the number of plots a farmer farms in a PWC. The first, called the *Weight* of the farmer in the PWC, refers to the surface area of agriculture in the PWC divided by the surface area of the PWC. This indicator is used to rank farmers in order of importance. It enables us to identify the farmers who must make the greatest environmental effort. It is positioned at PWC level.

The second indicator is the level of *Commitment* of the farmer to the PWC policy. It is calculated as the proportion of the farmer's land area present within a PWC. Here, we adopt the farmer's viewpoint and examine how this policy impacts them on a daily basis. We can hypothesize that their willingness to engage and provide environmental effort depends on their level of commitment. A farmer who owns 1% of their land in a PWC will not be as affected as a farmer who owns 90% of their land within a PWC.

In our analysis, we will test these two hypotheses. First, we hypothesize that the more land a farmer has in an PWC, the higher the probability of converting to or remaining organic farming practices. Second, we hypothesize that the larger the PWC and the greater the number of farmers, the less likely a farmer will be to provide environmental efforts and therefore, the less likely they are to convert to organic farming.

3. Data and methodology

3.1. Data construction

Organic farming in PWC: 2016-2021

For our national-level analysis, we utilize three databases. First, we use the French *Land Parcel Identification System* (LPIS) from 2016-2021[5]. This non-anonymized cartographic database provides us with the geographic locations of all agricultural surfaces for farmers receiving aid from the first and/or second pillars of the European Union's Common Agricultural Policy, along with information about their agronomic management (organic or conventional) and contractual agreements with AES. Finally, we use the PWC database [6] produced by EauFrance, which provides us with the official delineation date and geographical framework of each PWC. By merging the PWC map with the LPIS, we can determine whether each farmer possesses land within a PWC.

To test the hypotheses regarding the influence of being a local leader on environmental effort (Glowacki and von Rueden, 2015, Limbach and Rozan, 2022), we include the variable *Weight*, which refers to the proportion of a farmer's agricultural surfaces within the total size of the PWC. We include also *Commitment*, corresponding to the proportion of the farmer's farmland in the whole catchment. We hypothesize here that the willingness to make the environmental effort of converting to (or remaining in) organic farming will be positively influenced by these two variables.

3.2. Control group creation: Spatial RDD

We need to identify a counterfactual group, in order to determine what would have been the level of organic farming in the area without the PWC policy; or what would have been the farmer's farming practice if he hadn't had land in PWC. To do this, we will exploit the geographical perimeter of PWC, corresponding to the use of Spatial Regression Discontinuity Design (Keele and Titiunik, 2015, Lee and Lemieux, 2010)

The determination of PWC is exogenous to the farmers' decision, as it is decided following a hydrological study. Thus, at the boundary of this zone, two farmers will have the same probability of receiving the

[5]Access through the *Centre d'accès sécurisé aux données*
[6]Available on the https://geo.data.gouv.fr/fr/datasets/6e49bfb6f2d5fa2b3b62ec6b93703c043bffd8fc

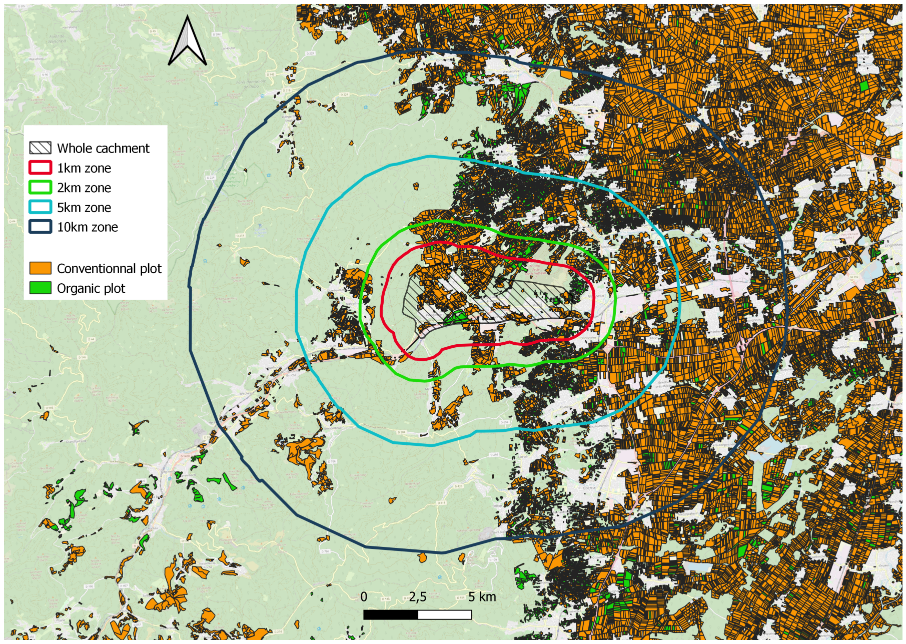

Figure 2: Creation of control groups based on distance from the PWC

treatment. It is not the farmer's behavior that has enabled him to receive the treatment. Indeed, as this division does not follow the administrative division, it is possible for a farmer to own plots in a PWC while his neighbors do not. By comparing two neighbouring farmers, one benefiting from PWC actions and the other not, we can observe the difference in their behavior, which will be attributable solely to the fact of having received the treatment or not.

We will then seek to demonstrate that treated and untreated farmers have similar characteristics, differing only in the fact that they farm land on PWCs. So if there is a difference in behavior between two neighbors, it can only be explained by the positioning of the land in a PWC.

To test the persistence of the effect, we formed 4 control groups, referring respectively to farmers with land within 1km of the PWC boundary, between 1 and 2km, between 2 and 5km; and between 5 and 10km (as indicated in the map 2). The hypothesis being that with distance, the differences between the treatment and control groups will increase.

3.3. Method

Our approach will distinguish between two points of view. The first, or observed reference unit, will be the PWC. The second will take the farmer as the reference unit. The econometric methods used will vary only according to the point of view, and we develop them here.

Delimitation year	2016	2017	2018	2019	2020	2021
# of PWC	533	98	30	22	488	44

Table 1: Years of PWC perimeter definition

Organic farming in PWC: Difference in Difference With multiple Time Periods

The geographical perimeter of all PWCs was not defined at the same time, for two reasons. Firstly, there have been two identification phases, the first with the identification of 500 PWC in 2009, then the identification of just over 500 following the SDAGE 2016-2021. Then, the implementation of this policy depends on the coordination and dynamism of the various actors in the territory, as well as the size of the catchment. Thus, for our 2016-2021 period, new PWCs are defined every year. This delimitation date is set by a prefectoral decree. The date for each PWC is available on the PWC en france website. The table 1 shows considerable heterogeneity in the timing of treatment. The year 2016, in fact, refers to all PWC delimited before 2016, since the database starts in 2016, all previous delimitations are assigned to 2016.

In order to analyze the impact of a policy on a variable of interest, here the share of organic farming, when individuals are not treated in the same year, we can't use the classic Difference-in-Difference method. To overcome this problem, we use the DiD with Multiple Time Periods method developed by Callaway and Sant'Anna (2021). In this method, groups are defined based on the period during which a unit is treated (the period here corresponds to the year in which the PWC perimeter was defined). The authors develop an estimator called *Group-Time Average treatement effect* that allows us to observe differences in the treatment effect as a function of the treatment period.

Thus the Group-time average treatement effect corresponds to :

$$ATT(g,t) = E[Y_t(g) - Y_t(0)|G = g] \tag{1}$$

Where $Y_t(g)$ is the average share of organic area, in year t, for the group of areas treated in year g; and $Y_t(0)$ designates the average share of organic surface for untreated areas (which will never be treated + areas not yet treated at period t)

This method allows inter-temporal comparisons of treatment effects within and between zones. In other words, we can detect heterogeneous effects depending on the time of treatment, as well as the persistence of the effect over time.

Farmer change behavior: Logistic with individual fixe effects

We will examine the impact of temporal variations in different PWC indicators, and how they relate to the probability that a farmer will convert to organic farming or remain organic in year t. As the decision to convert also depends on variables not included in the model, it is pertinent to control for individual heterogeneity. Stammann et al. (2016) proposes using binary choice models that take individual effects into account in the form of Equation 3.3. We calculate the marginal effects using the method described by Fernández-Val (2009), as shown in Equation 3.3.

$$N = \sum_{i=1}^{N^*} 1[0 < \sum_{t=1}^{T} < 1] \text{ (Sélection Echantillon)}$$
$$Pr(y_{it} = 1|x_{it}, \alpha_i, \beta) = \frac{1}{1+\exp^{-\alpha_i - x_{it}\beta}} \text{ (Logit Model)}$$
$$Pr(y_{it} = 1|x_{it}, \alpha_i, \beta) = \Phi(\alpha_i + \beta x_{it}) \text{ (Probit Model)}$$
$$y_{it} = 1[\alpha_i + x_{it}\beta + \epsilon_{it} > 0]$$

(2)

$$m_k(x_{it}, \beta, \alpha_i) = \frac{\partial Pr(y_{it}=1|x_{it}, \alpha_i, \beta)}{\partial x_{itk}} \quad \text{Individual Partial effect}$$
$$APE_k = \frac{1}{T}\frac{1}{N}\sum_{i=1}^{N*}\sum_{t=1}^{T} m_k(x_{it}, \beta, \alpha_i) \quad \text{Average Partial effect}$$

(3)

This method makes it possible to exclude observations where there has been no change in agronomic practices, making it easier to isolate the effect of exogenous variables on the decision to change. This approach is applicable given the large size of our population (333,176 individuals) and the 6-year observation period.

4. Results

4.1. Whole cachment level

According to Callaway and Sant'Anna (2021) and the *did* package on R, the Difference en Difference with multiple time period method allows us to compare the effect of treatment according to the year of treatment over the period. We're looking to explain the organic share of the area, i.e. the area under organic farming as a percentage of the total area. The control groups chosen are the same as those shown in the explanatory map 2, i.e. the 1km zone around the whole catchment area, the zone between 1 and 2km, between 2 and 5km, and between 5 and 10km. The following results deal with the effects for the groups treated in the years 2017, 2018, 2019 and 2020. As our LPIS data only covers the period 2016-2021, we have to exclude the groups treated in 2016, 2021 and 2022, as we are missing either the organic share before treatment (2016) or after treatment (2021 and 2022).

Treated group	2017	2018	2019	2020	All Treated
Control group(1)	-0.15*	-0.18*	0.01	0	-0.003
Control group(2)	-0.15*	-0.19*	0.01	0	-0.004
Control group (3)	-0.15*	-0.18*	0.01	0	-0.004

$^*p < 0.001$;

Control group (1): 1km control + 1:2km control + 2:5 km control + 5:10km control;

Control group (2): 0:10km group ; Control group (3): 1km group control only

Table 2: Average Treatement on the treated Group Effect

The results of the table 2, indicate that on average over the period studied, the proportion of organic produce in PWC is indifferent to that in control areas. However, if we look in detail, it appears that the areas treated in 2017 and 2018, i.e. 128 areas (98 in 2017 and 30 in 2018), have significantly less organic produce than untreated areas. When we look at the graph 3, using the results of the *Group-Time Average treatement effect* $ATT(g, t)$, we can see that from the treatment year, there is a deviation between the organic share in the control groups and the group treated in t. In contrast, for the group treated in 2019 and 2020, the organic/conventional share follows the same trend as the control group. At the same time, for the groups treated in 2019 and 2020, the distribution between organic and conventional land follows the same trend as for the control group. These results do not vary following changes in the control group.

The graph 4, shows that, across the entire database, the proportion of organic farmland in treated and control areas begins to drop off in the second year after treatment (between 0.5% and 2%). This effect can be explained by a significant increase in organic production in control areas, compared with a slower rate in treated areas.

4.2. Farmers level

In order to confirm the results obtained at whole catchment level, we are changing the gradient to observe farmers' behavior. Over the period 2016-2021, we will observe who the organic farmers are and how the treatment influences farming practice. We will use control groups constructed by geographical border to compare the behavior of neighboring farmers.

The table 3 shows a significant increase in the number of farmers impacted by the PWC policy, rising from 10.7% of farmers to 17.5% over the period, while at the same time the number of farmers fell by 8%.

In order to process this panel, we will first use a standard logit model over the entire period. This model does not take into account individual heterogeneity, as it treats the data as if the individuals were different from one period to the next. Nevertheless, this model has the advantage of not losing any observations. In this way, the quasi-exhaustiveness of LPIS data will be exploited, and we'll be able to compare the differences in characteristics between organic and conventional in France.

This analysis is completed by logit model with individual fixed effects (Stammann et al., 2016). This

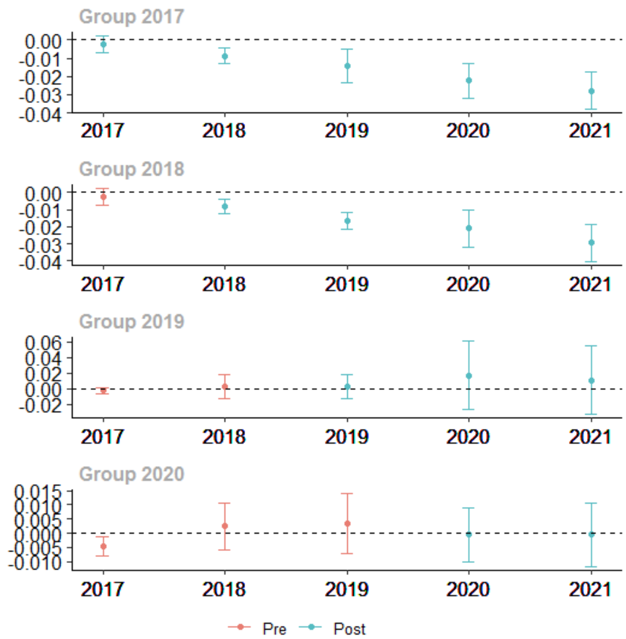

Figure 3: Average Treatement on the treated Group Effect by year

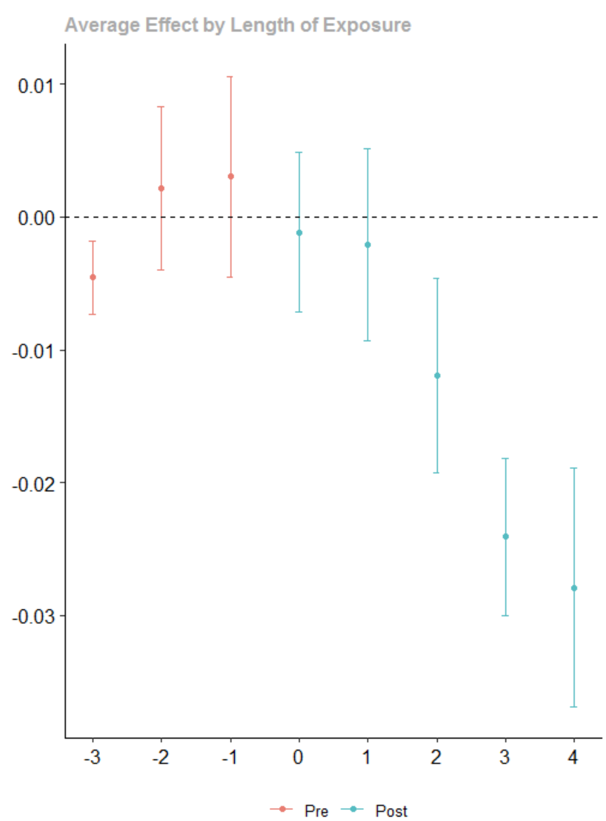

Figure 4: Average effect by length of Explosure

method has several advantages in the case of panel data when the variable of interest is binary. Firstly, it allows controlling for individual heterogeneity, highly relevant here as it allows for the inclusion of unobserved characteristics. In addition, in our case, we have very little information on the farmers. This method will enable us to observe more precisely the changing characteristics, from one year to the next, that influence the decision to switch production mode.

The model (2) of the table 4 presents the average Partial effect for Stammann et al. (2016) method, i.e. individuals who changed their farming practices at least once between 2016 and 2021. Out of 19536 farmers who changed practices, 82.8% switched to organic farming during this period, 6.5% switched to organic and then reverted back to conventional farming, and 10.7% started the period in organic farming and returned to conventional farming.

The coefficients of models (1) and (2) in the table 4 are not interpreted in the same way. In the first model, as the longitudinal dimension is not taken into account, interpretations are inter-individual, whereas in model (2) interpretations are intra-individual. For example, for the "Tot Area" variable, model (1) indicates that the larger a farmer's farm, the less likely he is to convert to organic farming. Model (2), on the other hand, indicates that if the farmer has increased the number of plots farmed from one year to the next, corresponding to a period of development on his farm, then that year he will be more likely (+4%) to go organic than the previous year. The results also show that the number of conversions to organic farming increases over time. Indeed, in France between 2016 and 2021, the growth rate of the number of organic producers was 12.7% (Agence Bio, 2022).

The results of the table 4 indicate a significant impact of the PWC policy and the development of organic farming, but the impact is ambiguous depending on the indicator. As we have already seen, when a farmer becomes treated, the probability of converting to organic farming drops significantly. This result can also be interpreted as an increase in the probability of deconversion (from organic to conventional farming). This effect was highlighted in a previous analysis of an organic farming survey in *Grand Est*, French region (see Appendix 1).

Model (1) informs us that the more the farmer is involved in the PWC policy, i.e. the more the farmer's share of agricultural land is in a PWC, the more likely it is that the farmer will go organic. Modelling (2) shows that if, from one year to the next, the share of land held in a PWC increases by 1%, then the probability of the farmer switching to organic farming increases by 5%. The two models also seem to validate the hypothesis of a change in leader behavior. Indeed, the more a farmer is considered as the leader of a specific whole catchment, i.e. holding the majority of agricultural land in this whole catchments area, the more likely the farmer is to convert.

	2016	2017	2018	2019	2020	2021
Farmer in PWC	10.7%	13.0%	13.5%	13.8%	17.5%	17.5%
1km	3.0%	3.7%	3.8%	3.9%	5.3%	5.3%
1-2km	2.7%	3.3%	3.4%	3.5%	4.6%	4.6%
2-5km	7.7%	9.1%	9.3%	9.5%	11.9%	11.9%
5-10km	11.5%	13.4%	13.6%	13.8%	16.1%	16.1%
+ 10km	64.4%	57.5%	56.4%	55.5%	44.7%	44.7%
# Farmers	346189	337584	330415	325557	322213	318342

Table 3: Distribution of farmers by distance from PWC and year

	Logit pooled (1)	Logit with fixed effects Average Partial effects (2)
Tot Area	-0.01***	0.04***
PWC zone (ref=+10km)		
PWC	-0.28***	-0.98***
1km zone	-0.15***	0.04
2km	-0.08***	-0.07
5km	-0.05***	-0.21*
10km	-0.01·	0.07
Comittement	0.001***	0.05***
Weight	0.01***	0.05**
Intecept	-2.45	
YEAR	+	+
N		19536
Obs	1980300	105155

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 4: Impact PWC on the farming practice. Logit model with individual fixed effect, period 2016-2021

5. Conclusion

Our preliminary results indicate that the location of farmland within a PWC decreases the likelihood of farmers converting to or remaining in organic farming. In fact, the border areas of the PWC have the same rate of development of organic farming, while for some border areas the development of organic farming over the period is 0.5 to 2% higher. This surprising result can be explained by two mechanisms: free riding behavior, whereby farmers in larger PWC leave the environmental effort to other farmers in the area. Moreover, these are not regions with a long history of organic farming, so changes in farming behavior are more marginal.

Even so, it's important to note that when the weight and/or the commitment of the PWC policy on the farmer's activity is significant, farmers participate in the environmental effort and convert land to organic farming.

The next step in our research will be to compare the different action plans implemented in PWC. Indeed, depending on the location, the characteristics of the area, the timing and the stakeholders involved, different instruments could be mobilized (AES, property actions, regulatory measures). Nevertheless, to carry out such a study, the national approach may be compromised.

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6. Appendix

Appendix 1: Priority whole catchment and organic farming remaining in *Grand-Est* region

We will examine the data collected during a survey conducted by the Chamber of Agriculture of Grand Est between 2021 and 2022, targeting farmers engaged in organic farming between 2016-19 in Grand Est. The survey was carried out between March 2021 and March 2022, and the targeted farmers were asked to respond online or by phone. Multiple reminders were sent, and ultimately, 726 farmers responded, resulting in a response rate of 59%. The aim of this 25-question survey was to study the sustainability of organic farms.

Among the respondents, 12.8% expressed a *Very likely* or *Maybe* intention to stop practicing organic farming, and 7.5% expressed a *Very likely* or *Maybe* intention to decrease their agricultural land area. Moreover, 25.9% of respondents cultivate at least one land in PWC.

To determine the influence of being located in an PWC on the probability of staying in organic farming, we choose to model the intention to stop practicing organic farming or to decrease it by a probit model, given by equation 6. The interpretation of the conditional effects will allow us to observe how the intention of organic farmers is influenced by the explanatory variables of the model.

$$\text{Pr(Decrease/Stop} = 1\text{—X)} = \Phi(X\beta) = \Phi(\beta_0 + \beta_1 PWC + \beta_2 X_2) \ (4)$$

- $\Phi(.)$ fonction de répartition Normal standard

According to Table 5, it appears that organic farmers located in PWC in the Grand Est region have a higher probability of reducing or leaving organic agriculture. Other findings suggest that farmers who initially converted to organic farming for environmental reasons and who have contact with other organic farmers are more likely to stay in organic farming.

	Stop (1)	Decrease (2)
PWC	0.83**	1.01**
Surface (ha)	0	0
# Employee	0	0.04·
Environmental motivation	-0.56·	-0.61·
Health motivation	-0.36	-0.64·
Organic network	-1.03***	-1.15***
Distribution Channel (ref: Short channel)		
Short &Long	0.29	-0.76
Long	0.82*	0.27
Intercept	-1.43**	-1.4*
# Obs	617	619
% True Prediction	89.6%	91.8%
% True Prediction:1	3.1%	4%

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{\cdot}p < 0.10$

Table 5: Decision to stop or decrease OF area, probit analysis