Comparative analysis of revenue and land prices between organic and conventional farming

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Abstract

To satisfy the objectives of the European Green Deal, a quarter of the EU's agricultural land should be organic by 2030, compared to 8.5% today. France, the largest European country in terms of agricultural production, must become a major player in this transition. However, French farmers are hesitant to convert because of the uncertainty of whether organic farming will improve their income or not. We will conduct a double comparative analysis between the differences in income (on 103,000 observations distributed between 2004 and 2019) and the differences in the value of agricultural land (33,000 transactions between 2015 and 2019) between organic and conventional farmers.

The study shows that the current monetary incentives for conversion are very low. Panel data modelling using the Breusch-Mizon-Schmidt estimator shows no difference in income between organic and conventional farmers, despite higher subsidies and lower costs for organic farmers. Furthermore, using an OLS regression including Ricardian theory and residential rent determinants, it is demonstrated that organic land is sold for the same price as conventional land. This result is confirmed by the Spatial Matching method, showing that organic practice does not influence the price of land. The article shows that it is necessary to consider whether the land is organic or not when selling agricultural land. Such differentiation in the market can help to integrate environmental externalities (better soil quality) into the land value. This price increase could encourage land conversion through an anticipated increase in farmers' income. However, at present, the low supply of organic land for sale does not allow this price increase.

Keywords: `Organic premium, Farmland price, organic farming, European Green Deal, agricultural economic performance`

`JEL classification: C23, Q15, R14`

1. Introduction

According to Muller et al. (2017), organic farming (OF) is an agriculture that allows to respond to demographic challenges, i.e. to feed 9 billion people by 2050, while respecting the environment. The main challenge is to convert the world's farmers to OF practices (regulated by the European Commission's regulation n°834/2007). Indeed, according to Agence Bio (2020), only 1.4% of the world's surface area was

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cultivated organically in 2017. At the European level, the objective of the European Green Deal is to reach a quarter of the organic surface area by 2030, compared to 8.5% in 2020. For Latruffe et al. (2013), the main obstacle to the conversion of farmers is the financial constraint, the fear of losing income compared to the conventional situation. It is therefore interesting to observe whether the fears of conventional farmers are founded or not.

The aim of the article is to answer the following question: Is OF more profitable than conventional farming ? To answer this question we will analyse two components of the profitability of an activity: the income (represented by the annual economic performance of farms) and valuation of the land (estimated through the sale price of the land).

In this study we will focus on the case of French agriculture, the country for which the challenges of OF are the most important in the EU. The European Union is the world's largest agricultural power with an estimated production of €418 billion in 2019[2], thanks in particular to France, the leading contributor with 18.55%. France, Germany, Italy and Spain represent 60% of the EU's agricultural production in 2019. Within the European ranking of countries by the share of organic surfaces, France is the last (7.5% in 2018 against 15.5% for Italy and nearly 10% for Germany and Spain). Thus, it is in France that the potential for conversion is the greatest. Furthermore, according to the simulations of the PARCEL platform [3], if the diet decreases by 25% the share of animal proteins, the agricultural surfaces of France converted to organic farming, would be able to feed the population.

In the meta-analysis of Crowder and Reganold (2015), after analysing 44 studies from 14 countries, they found that the economic performance of organic farmers was superior to that of conventional farmers. However, as this article is not based on French studies and does not include subsidies, the replicability of this study to the French case does not seem relevant. To address this, we will compare the economic performance of 102113 French farmers (including 3566 organic farmers) between 2004 and 2019. The analysis will focus on different indicators such as yields, sales prices, subsidies received, production costs and economic results. The econometric strategy based on a panel data regression with correlated individual effect will control for farm characteristics as well as for soil and climatic characteristics.

The difference in the value of agricultural land between organic and conventional farmers, is only addressed in the article of Fuller et al. (2021) with a study on the United States. In this study, it is found that in the United States between 2003 and 2011, organic land sold for 26% more than similar conventional land, or $72/ha. In our study, after creating the database to distinguish between land sold according to agricultural practice (organic or conventional) we will analyse the determinants of price formation. We will

[2]Eurostat press release 14/09/2019

[3]This tool calculates the agricultural land required for food production and its effects on greenhouse gas emissions, biodiversity and employment. The tool also allows simulations based on a reduction of the share of animal protein in diets. The tool is available on the website: https://parcel-app.org/

separate the factors from the Ricardian theory of agricultural rent and the factors from the residential rent theory. The first type of factor refers to Ricardo's theory (Ricardo (1817)), which says that the value of land is equal to its productivity, and the residential factors refer to the value of agricultural land on the day it is sold for residential use (Cavailhès and Wavresky (2003)). The analysis of the database of 33,000 sales (of which 2161 are organic farmers) will be done in two steps. First, an OLS regression will allow us to observe the influence of the Ricardian rent as well as the residential rent on the formation of the land price. Secondly, in order to make the distribution of the treatment (the organic practice) random, each organic land is matched to the closest conventional land. Then, the price of the land, is compared to observe the influence of the organic practice on the price.

2. Economic difference between organic and conventional farming: a literature review

Here we will present the main determinants explaining the differences in income between farmers. Firstly, by developing the theoretical differences between the economic performances of farmers. Then, we will discuss the different variables that explain the formation of agricultural land prices.

2.1. Economic performance

If we simplify, a farmer's income is equal to his product (price x quantity) minus his total costs, i.e.: $i = P * Q - TC$. It is therefore interesting to observe the differences in each parameter between the two farming practices.

First of all, there are differences in yields between OF and conventional farming (CF). According to meta-analyses of Ponisio et al. (2015), Seufert et al. (2012), respecting OF regulations leads to an average yield loss of between 10 and 18% after the conversion period, mainly due to the non-use of chemical inputs. However, when comparing the different types of production (e.g. cereals, orchards, market gardening, etc.), they find that for some productions the yield differential is not significantly different (orchards) whereas it is -30% for cereals for example.

The median price difference between organic and conventional products is about [29;32]%, according to Crowder and Reganold (2015). According to them, the price differential that would guarantee a similar situation between the two practices would be about 7%. There is therefore a strong monetary incentive to convert to OF. This differential should theoretically allow for a return on the years of conversion, the costs of certification and other costs incurred by the market change.

Concerning total costs, it is interesting to decompose this indicator. Indeed, in the analysis of Crowder and Reganold (2015), they find that the amount of costs incurred by an organic farmer are not significantly different from those of a conventional farmer. However, the composition of the costs is different. On the one hand, due to the organic regulation, farmers will drastically reduce their purchases of chemical inputs. On the other hand, they will increase the cost of labour (by 7% according to the study). OF requires more work for the same area than CF (increased work due to the prohibition of pesticides, more administrative work).

From this, the authors conclude that organic farmers make between 22 and 35% more profit. This performance can be explained by a higher selling price, which allows to compensate for the yield loss caused by the conversion. We can question the replicability of these results in the French case. First of all, of the 44 studies, only 4 are from European Union countries (Spain, Greece, Norway and Croatia) and the 44 studies selected do not include government subsidies. However, In the case of France, the Common Agricultural Policy is very active. In 2020, each French beneficiary received an average of €18482. A comparative study based on French data therefore seems relevant.

2.2. Determinants of agricultural land prices

For Cavailhès and Wavresky (2003), the price of agricultural land is equivalent to the capitalisation of its future rents. These future rents can be of two kinds, agricultural rents (the income from the cultivated land) and the residential land rent. The latter refers to the value of the parcel if it's sold for residential use. According to Levesque (2007), in France this residential rent is 10 to 50 times higher than the sale price for agricultural use. Two cases are possible: either the farmer anticipates that his land can never be converted to residential use (for example, too isolated), in which case the price will depend solely on future agricultural rents. If he anticipates a future conversion of the land to residential use, then the sale price will depend on the productive but also geographical characteristics of the land.

Ricardian rent

First of all, let us look at the determinants of Ricardian rent and more precisely at the impact of soil and weather conditions on yields. For Ricardo, the value of land depends on its capacity to produce. Thus, several factors will impact the productivity and therefore the value of a land, the weather, the properties of the soil, whether physical (slope, altitude, subject to erosion) or chemical (nitrogen and carbon content, etc.), as well as the type of farming (mechanical work, chemical fertilization).

Currently, and in response to current environmental issues, the impact of weather conditions on agricultural production is the subject of important research. It was in particular Mendelsohn et al. (1994) who first studied the impact of global warming on agricultural production.They found that the increase in temperature will lead to changes in crops. Indeed, at a given temperature, yields depend on the type of crop chosen, so plants that prefer soft climates will be replaced by plants with high yields during warm periods [4]. This increase in temperature thus forces farmers to choose crops that are less and less profitable, explaining the

[4] In the article by Mendelsohn et al. (1994), they give the example of wheat, which is replaced by maize and then by pasture as the temperature increases

negative relationship between temperature and land value.

Also, Passel et al. (2016) obtains, in an analysis of European farms, that according to the different scenarios[5], the farms of Southern Europe will suffer more from global warming. Indeed, this generalised increase in temperature will benefit the northern European regions, which will see their production increase, whereas the southern regions, which are already warmer, will see their production decrease. Indeed, as the relationship between agricultural production and temperature is reversed U-shaped, the northern countries converge towards the maximum production, while the southern countries are on the other side of the curve and therefore moving away from the maximum production. It is also important to see the seasonal impact of this rise in temperature, as warming in spring and autumn has a positive impact on agricultural production (allowing an increase in the harvest period), but this warming has a negative impact on production in winter and summer (in winter, the cold limits the proliferation of diseases and crop pests, and during relatively cold summers the probability of drought is low). Concerning precipitation, according to the scenarios of Nakicenovic et al. (2000), this should increase allowing a marginal increase in production by avoiding mainly the periods of drought, nevertheless its increase during spring and autumn slows down the growth of the crops (the plants need sun during this period).

The type of farming can also impact on yields. Indeed, OF that prohibit the use of chemical inputs reduce yields. According to Ponisio et al. (2015), the differences in yields between the two types of agriculture are of the order of 20% (which can be null for orchards).

Residential rent

The value of the residential rent corresponds to the anticipated value of the land on the day it is converted to residential use. According to Cavailhès et al. (2011) (equation 4), the sale price of agricultural land is equal to:

$$P = \underbrace{\frac{R_A}{i}(1 - e^{-it^*})}_{\text{Ricardian rent}} + \underbrace{\Big(\frac{R_0 - \delta x}{i} + \frac{g}{t^2})e^{-it^*}}_{\text{Residential rent}} \qquad (1)$$

Where R_A denotes the agricultural rent, R_0 denotes the residential rent in the Central Business District (CBD), x the distance of the land from the CBD multiplied by δ the unit transport cost, g the population growth rate,i the discount rate and t^* the date of conversion to residential use.

So if we decompose the second part of the equation, we see that the residential rent depends on 3 parameters: the population growth rate, the distance to the central business district and the date of conversion to residential use.

Firstly, an increase in the anticipated demographic growth of the area where the land is located leads to an increase in future demand, and therefore to an increase in the amount of the residential rent on the day when the conversion is possible. Thus, as the population growth of dynamic cities is higher than that

[5]The article simulates three climate scenarios for the year 2100 based on the Giec 2000 report.

of isolated municipalities, a negative relationship can be observed between land rent and distance from the CBD. Nevertheless, this relationship is not linear, as shown in Cavailhès et al. (2011), there is a "village" effect. Thus, as we will demonstrate later in the analysis of the determinants of the sale price of agricultural land (fig.2), the smaller towns also play a role in attracting populations. This attraction is smaller than that of the large cities (the *CBD* in equation (1)), but by attracting jobs, they also create demand for housing and allow an increase in land prices.

The second factor influencing land value is the distance to the CBD boundary. When a city is dynamic, its population growth is important, and thus the urban planning authorities may decide to expand the city, i.e. to push the residential boundary.Thus, if agricultural land is located on the border of a dynamic city, the probability that the planning authorities will make this land buildable is high.

3. Methodology

3.1. Panel estimation

Panel data allow us to follow an individual over several periods. This type of data allows, compared to cross-sectional data, to control for unobservable individual or temporal heterogeneity, as well as to observe the dynamics of the dependent variable of our model.

Hausman-Taylor estimator

In our data we suspect that individual heterogeneity is correlated with the explanatory variables. Indeed, the individual characteristics of the farmer as well as his geographical environment, according to Padel (2001), Nguyen-Van et al. (2021), influence the practice of OF. However, the modelling of fixed effects by the estimator *within* here is not relevant for Hausman and Taylor (1981). Indeed, this estimator does not take into account variables that are constant over time. In order to overcome these limits, Hausman and Taylor (1981) proposes the following model:

$$y_{it} = X'_{1it}\beta + X'_{2it}\beta + Z_{1i}\gamma + Z_{2i}\gamma + \mu_i + \varepsilon_{it} \ (2)$$

Where, X'_1 and X'_2 refers to the time-varying variables of the model respectively uncorrelated and correlated with μ_i. As well as Z_1 et Z_2 referring to the time-invariant variables of the model respectively uncorrelated and correlated with μ_i.

The method consists in replacing the parameters of equation (1) by the following parameters:

- $\tilde{X}_{1it}$ by $(X_{1it} - X_{1i})$
- $\tilde{X}_{2it}$ by $(X_{2it} - X_{2i})$
- $\tilde{Z}_{1it}$ by Z_{1it}

- $\tilde{Z}_{2it}$ by $\overline{X}_{1it}$

It can be noticed that $\tilde{X}_{1it}$ and $\tilde{X}_{2it}$ correspond to the *within* estimator and that Z_{2it} is instrumentalized by the transformation *between* X_{1it}. We will also estimate the model using the estimators developed by Amemiya and MaCurdy (1986) and that of Breusch et al. (1989), both of which increase the precision of the Hausman-Taylor estimator by increasing the number of instrumental variables based on the hypothesis of strict exogeneity of the variables X_{1t} (i.e $E(\varepsilon_t|X_{1t}) = 0$ and $E(Y_t|X_{1t}) = X_t\beta$).

Hausman Test

Hausman (1978) proposes a method for testing the absence of correlation between the individual effect term and the explanatory variables. The test is based on the properties of the following two models, a fixed effect model with within estimator and a FGLS (Feasible generalized least squares) model with composite errors. Both estimators are unbiased and converge under the null hypothesis, but if the hypothesis of non-correlation between the individual effects and the explanatory variables is violated, then the second estimator is not convergent. Thus if the estimates of the two models are close, i.e. the two estimators are convergent and thus there is no correlation between the individual effect term and the explanatory variables. But if the estimates are far apart, then this implies that one of the estimators diverges (the FGLS model) and therefore there is correlation between the individual effect term and the explanatory variables. Formally, Hausman (1978) constructs the following test statistic:

$$Q_H = (\hat{b}_{within} - \hat{b}_{FGLS})'[\hat{V}(\hat{b}_{within}) - \hat{V}(\hat{b}_{FGLS})]^{-1}(\hat{b}_{within} - \hat{b}_{FGLS}) \quad (3)$$
$$Q_H \rightsquigarrow \chi^2_{\#regressors_{ddl}}$$

Where $\hat{b}_{within}$ and $\hat{b}_{FGLS}$) refer respectively to the estimates by the fixed and random effect models. Under the null hypothesis, both estimators are convergent. According to Hausman (1978), if Q_H is greater than the fractile of the Chi-square distribution, then the null hypothesis is rejected and the FGLS estimator is not convergent.

Since the within estimator does not take into account the time-invariant explanatory variables, the previous test does not allow us to know if the time-invariant variables of the model are correlated or not with the individual effect term. To do this, we will replace the within estimator by one of the instrumental variable estimators (Hausman-Taylor, Amemiya and MACurdy, and Breusch-Mizon-Schmidt) in the Hausman test (3). Thus we obtain:

$$Q_H = (\hat{b}_{IV} - \hat{b}_{FGLS})'[\hat{V}(\hat{b}_{IV}) - \hat{V}(\hat{b}_{FGLS})]^{-1}(\hat{b}_{IV} - \hat{b}_{FGLS})$$
$$Q_H \rightsquigarrow \chi^2_{\#regressors_{ddl}}$$

If Q_H is greater than the fractile of the Chi-square distribution then the null hypothesis is rejected, and thus the FGLS estimator is not convergent and thus the time-invariant explanatory variables are correlated with the individual effect term.

Panel length	Frequency	Percentage
1	4284	0.18
2	3347	0.14
3	3127	0.13
4	2513	0.11
5	2075	0.09
6	2001	0.08
7	3671	0.15
8	725	0.03
9	2042	0.09

Table 1: Unbalanced panel description

3.2. Spatial matching

3.3. Database

Farm Accountancy Data Network

The Farm Accountancy Data Network is a database covering the period 1979-2020 composed of the accounting and socio-economic data of a representative panel of farmers in France. The sampling method is based on a stratification with three criteria, the region (NUTS-2 level), the type of agricultural activity (15 categories) and revenues (5 categories). It should be noted that only farms with a standard gross production of more than 25,000€/year are taken into account (95% of french farms). We can see on the table 1, the distribution of the unbalanced panel of the FADN database. These data allow us to observe the diversity of incomes between farmers according to their surface area, their type of crop and their agricultural practice.

For our study, we take into account the following variables: *AWU*, i.e. the number of annual work units, *Subsidies*, the amount of subsidies received by the farmer, *Total Cost*, the amount of total costs paid by the farm and *GOS*, which designates the Gross Operating Surplus, i.e. revenue less costs and taxes.

In order to calculate the yields and sales prices, we have for each production the quantity produced per year by nature of the product , as well as the size of the agricultural area allowing this production and the total sales price of this production. Thus by the following calculation we obtain the price of each crop and its yield:

$$Y_{ico} = Q_{ico} * A_{ico} \quad (4)$$

$$P_{ico} = \frac{R_{ico}}{Q_{ico}} \quad (5)$$

with i={1; 102100}   c={1;27}

$$o = \begin{cases} 1 & \text{if organic practice} \\ 0 & \text{if conventional practice} \end{cases}$$

Where Y, Q, A, P and R are respectively the yields, the quantities produced, the areas assigned, and the revenues of the farmer i growing the plant c and following the production method o (organic or not).

Land Value Request and Graphical Land Register

For the second part of the analysis, i.e. the comparison of land valuation between farmers, we had to create an original database. Indeed, in France, the organic character of a land at the time of the sale is not specified. This database could be built from two existing databases, *Request for land value* and the *Graphic land register*.

The first database, *Request for land value* [6], lists all land transactions (sale of houses, land, agricultural plots) carried out in France over the last 5 years (excluding the 4 French departments Moselle, Bas Rhin, Haut Rhin and Mayotte). It is produced by the General Direction of Public Finances, and includes for each transaction the sale price (excluding notary fees), the surface and the GPS coordinates of the land. The second database, the *GLR*(Graphical Land Register), annually refers all the agricultural land receiving CAP aid.It is produced by the French Service and Payment Agency, and since 2015, in addition to knowing the GPS positioning, the surface area of each parcel, and the type of production, it makes it possible to know whether the land is farmed conventionally or organically.

Thus, from the first database we extracted all sales of agricultural land without buildings.These parcels were merged with the *GLR* database for the year of sale, allowing us to know whether the land was farmed organically or conventionally at the time of sale. Then we apply the clean data methodology adopted by the *SAFER* [7], consisting of removing sales involving areas of less than 0.7 hectares and removing outliers [8]. Finally, we have 33012 observations (30851 conventional and 2161 organic sales) between 2015 and 2019.

4. Empirical analysis

4.1. Comparison of economic performance

As in the paper by Crowder and Reganold (2015), we will compare the financial results of farmers with respect to the following indicators: income, yield, selling price, total costs and AWU and adding the amount of subsidies. From the FADN data between 2004-2019, we have 99444 conventional farmers and 3223 organic farmers. We have removed farms in conversion and mixed farms (practicing OF and CF).

[6] This database, called *Demande de valeur foncière* in French, is open access and available at the following address: https://app.dvf.etalab.gouv.fr/

[7] *Sociétés d'aménagement foncier et d'établissement rural* is an organisation in charge of the orientation of agricultural land. They are in charge of ensuring the proper functioning of the agricultural land market as well as the preservation of agricultural areas.They also publish an annual report, which includes the average prices of agricultural land at the sub-departmental level

[8] Removal outlier *SAFER* methodolgy:

$$|x - me(x)| < 1.5 * (Quartile_3(x) - Quartile_1(x))$$
$$\text{with x} = ln(\frac{Price}{ha}) \text{ and } me(x) = \text{median}$$

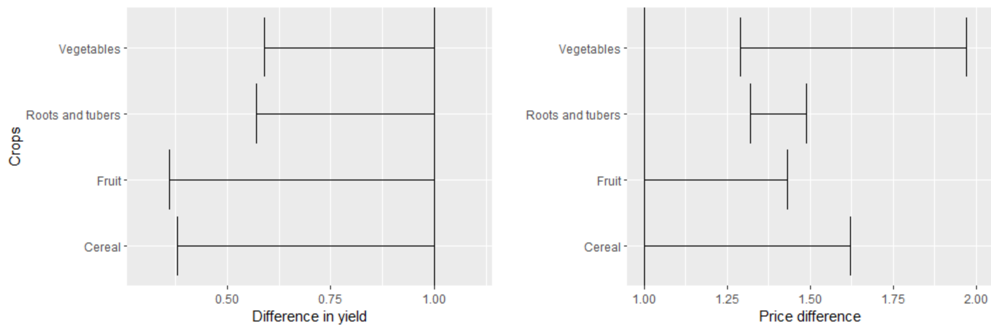

Figure 1: Yield and price comparison between OF and CF (25 types of crops)

For the study of yields and prices of products, we selected 27 types of products[9] (cereals, vegetables and fruits, see Appendix 2) and regressed on the types of farming practices and control variables. The results in the figure 1 indicate that the yield loss due to conversion ranges from -64% to no difference. Regarding organic selling prices, these ranged from similar to conventional prices to a doubling of prices.

	log GOS (1)	log Tot Cost (2)	AWU (3)	log Subsidies (4)
Farming characteristic				
Organic	0.01	-0.18***	0.16***	0.91***
Type of product (Livestock ref)				
Cereales	-0.07***	-0.01	-0.33***	0.04
Vegetables	0.48***	0.1***	3.52***	-3.5***
Winegrowing	0.058***	-0.43***	1.76***	-4.77***
Agriculture Area	0.005***	0.004***	0.006***	0.006***
Climatic characteristic				
Temperature Mean				
Summer	-0.08***	-0.03***	-0.006	0.06***
Winter	0.02***	0	0.01*	0.03**
Automn	-0.02***	0.007**	0.02**	0
Spring	0	-0.015	0.02***	0
Precipitation Sum				
Summer	0	-0.0001***	-0.0001*	0
Winter	0.0001***	0	-0.0002**	0.0001**
Automn	0.0001***	0	0	0
Spring	-0.001***	0	0	-0.0001***
Intercept	12.1***	11.1***	1.26***	7.4***
Type municipality	YES	YES	YES	YES
Year	YES	YES	YES	YES
R^2	0.12	0.18	0.06	0.15
Nb Obs	98843	102113	102113	102113
Estimator	BMS	BMS	BMS	BMS
H Test $\chi_{37}(\alpha = 0.001) = 55.73$	79	1675	263	174

Table 2: Profitability analysis, period 2004-2019, Breusch-Mizon-Schmidt Estimator

Then, the table 2, indicates that for all the specifications, the null hypothesis of the Hausmann test is

[9]In order to meet the following condition, at least 50 crops are grown by organic farmers

rejected indicating an influence of the individual characteristics on the dependent variable. The Breusch-Mizon-Schmidt estimator was also chosen over the Hausmann-Taylor and Ameniya-MaCurdy estimator, based on the maximisation of the R^2 criterion, insofar as the significance of the interest and control variables indicate similar results. The table 2 shows that OF does not significantly change the economic result of farmers (Gross Operating Surplus). Specification (3) tells us that OF practice requires 0.16 additional Annual Work Units, in accordance with the result of Crowder and Reganold (2015). Despite this increase in labour costs, it appears that OF have significantly lower total costs than conventional farmers, by about 18%. Finally, it appears that organic farmers receive almost double the subsidies of conventional farms. Concerning the meteorological impact on the economic results, it appears in accordance with the article by Passel et al. (2016), that a warm summer do not allow good economic results mainly due to drought episodes reducing the yields. The results also show that high precipitation affects the agricultural results. Finally, contrary to the results of Passel et al. (2016), a warm winter allow an improvement in the economic results of the farm.

4.2. Comparison of land valuation

Ricardian rent vs Residential rent

Using the original database containing the 33026 agricultural land transactions carried out in France between 2015 and 2019, we will first observe the predominant factors in the setting of land prices. Then, in a second time, after having matched the OF land transactions by a geographical matching we will observe the influence of the agricultural practice on the price.

The table 3 shows the results obtained by the OLS regression of the price per hectare of land sold as a function of the land characteristics relating to Ricardian rent (agricultural practice, elevation, weather) and relating to the geographical positioning of the plot, which makes it possible to approximate the residential rent (demographic growth, urbanisation rate). First of all, the practice of OF at the time of sale does not impact the sale price of the land (with a margin of error of 1%). It can also be noted that the average summer temperature has a significant impact on the price per hectare of agricultural land. This result is interesting because it shows that the residential rent has a greater impact than the Ricardian rent. Indeed, on the one hand, according to Mendelsohn et al. (1994), Passel et al. (2016), yields are lower during warm summer. And on the other hand, according to Grout et al. (2016), housing prices increase by 7.2% when the average temperature in July increases by 2°C. The positive coefficient of the summer temperature thus indicates that the loss of yield due to high temperatures is more than compensated by the marginal increase in residential rent.We also notice that the urban dynamism (rate of urbanisation, population growth) around agricultural land will positively influence the price of land, stimulated by an increase in residential demand. We also note by the table 3 and by the figure 2, the negative relationship that exists between the distance from the CBD and the price level of agricultural land. This result is in accordance with the village effect obtained in the article by Cavailhès et al. (2011).Indeed, depending on the size of the city[10], workers will try to live as close as possible to their jobs. This creates dormitory suburbs, i.e. people do not work in their place of residence.

	All Observation			Spatial Matching	Spatial-Year Matching
Dependant variable	log Price/ha (1)	log Price/ha (2)	Price/ha (3)	log Price/ha (4)	log Price/ha (5)
Ricardo rent					
Organic farming	-0.04*	-0.04*	-2.7	0.06	0
Elevation	-0.0003***	-0.0003***	-0.4	-0.0005***	-0.0004***
Temperature Mean					
Summer	0.2***	0.2***	1188***	0.08	0.2*
Winter	-0.4***	-0.4***	-2738***	-0.9***	-0.7***
Automn	0.7***	0.7***	4435***	1.1***	0.9***
Spring	-0.4***	-0.4***	-2572***	-0.3*	-0.4***
Precipitation Sum					
Summer	0.01***	0.01***	66***	0.005***	0.007***
Winter	0	0	0	0	0
Automn	0	0	4*	0.002***	0
Spring	-0.01***	-0.01***	-68***	-0.01***	-0.01***
Residential rent					
Urban classification (+10000 jobs ref)					
Surburb of 1 +10000 jobs	-0.4***		-2913***	-0.4***	-0.4***
Surburb of few +10000 jobs	-0.4***		-2778***	-0.4***	-0.4***
+5000 jobs	-0.2***		-1875***	-0.2	0.2
Surburb +5000 jobs	-0.5***		-3506***	-0.7***	-0.7***
+1500 jobs	-0.4***		-2579***	-0.3***	-0.4***
Surburb of 1 +1500 jobs	-0.6***		-3844***	-0.6***	-0.7***
Surburb of few +1500 jobs	-0.5***		-3509***	-0.6***	-0.6***
Isolated	-0.6***		-3652***	-0.6***	-0.7***
Pop growth rate 2012-17	0.3***		1435***	-0.0003***	0
Arti growth rate 2009-19		0.16***			
Intercept	6.87***	6.03***	-7252***	4.7***	5.2***
Year	YES	YES	YES	YES	YES
R^2	0.12	0.11	0.09	0.18	0.15
Nb Obs	33026	33034	33026	3634	4251

Table 3: Farmland price decomposition, OLS regression and spatial matching

However, we can suspect problems of multicollinearity between the variable *Organic farming* with the variables *Elevation* and *Urban Classification* according to Nguyen-Van et al. (2021), Allaire et al. (2014). Indeed, the pedological conditions as well as the positioning of the plots in relation to the urban pole, influence the practice of OF.

Spatial Matching

To respond to this limitation we perform spatial matching. The idea is to compare the sales price of an organic land with that of the nearest conventional land. This method allows to compare two observations

[10]Classification developed by INSEE, classifying French towns according to the number of jobs available (more than 10,000 jobs, more than 5,000 jobs, more than 1,500 jobs)

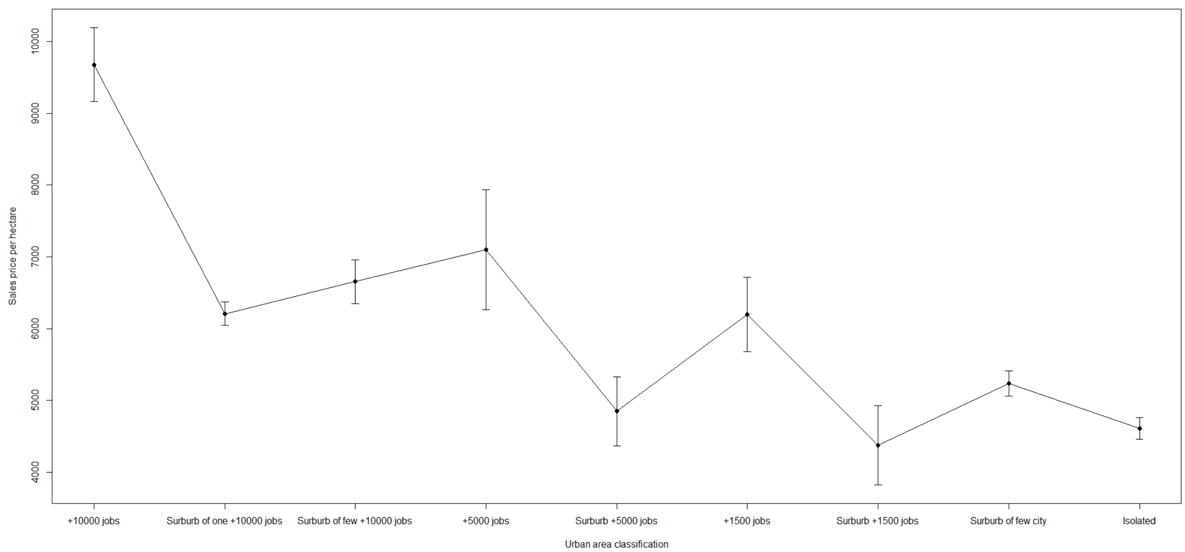

Figure 2: Average price of sales per urban classification

with the same spatial and soil characteristics, so the distribution of the treatment (OF practice) becomes random.

Like the matching of Heckman et al. (1997), the principle is to associate two observations which differ only with respect to the treatment variable. The objective here is to move from a treatment that was correlated to individual variables to a randomly distributed treatment. Nevertheless, like Propensity score matching, we do not associate two observations with the same probability of receiving the treatment but two observations with the greatest geographical proximity.

The 2175 organic transactions were matched with their closest conventional transactions. This type of matching allows to compare observations with similar soil and climatic characteristics, and also with an identical land market. Reinforced by the fact that the average distance of the matches is 1.6km (median 1.28km, 2.17km for 3rd quartile). In order to increase the robustness of the method, we perform a second matching. As the market for agricultural land may have been subject to cyclical changes between 2015 and 2019, we assigned each organic transaction to the closest conventional transaction in the same year. This matching based on the additional criterion of year of sale logically increases the average distance between the two matched lands from 1.6km to 4.5km (median 3.7km and 3rd quartile 5.9km). This method reduces the selection bias in the sense that since these two observations are identical they have the same probability of receiving the treatment, thus the distribution of the treatment becomes random. Once each treated observation is associated with its control observation, we again regress the price of the land against the agricultural practice and the control variables.

The results of the table 3 (specification 4 and 5) are consistent with the previous results. Indeed, after matching the organic land based on the geographical criterion (specification 4) and on the year of sale combined with the geographical proximity (specification 5), we obtain results similar to the first three specifications. Thus, when we randomize the distribution of the treatment, the practice of OF, we obtain that the organic character of a farmland has no effect on its sale price.

5. Discussion on the organic farmland market

The results show that organic land is currently sold at the same price as conventional land which is surprising as the environmental quality of organic land is superior to conventional land. The high quality of land used in OF is mainly due to three practices: crop rotation, permanent cover and fertilization with compost and green manure. These practices increase the provision of ecosystem services such as increased carbon sequestration in the soil, increased production of organic matter, increased water storage capacity of the soil and reduced erosion.

These theoretical elements are verified by field studies and meta-analyses. Indeed, Underwood et al. (2011) conducted a meta-analysis of 22 articles comparing the soils and environment in OF and CF, and obtain that organic land has more species (in number and diversity). Organic soils have also a better carbon storage capacity according to Gattinger et al. (2012) and because of the permanent cover of the soil, Reganold et al. (1987) found that the erosion of organic land is less important than that of conventional land. Finally, for Sautereau and Benoit (2016), organic land has a higher capacity to store water (allowing for better yields in times of drought). As the productivity of agricultural land depends, among other things, on its quality, which is defined by different parameters (microbial activity of the soil, quantity of biomass, quantity of carbon contained in the soil, level of organic matter, etc.), we obtain that the organic land yields are constant over time, whereas th conventional land yields decrease through the use of chemical inputs. Indeed, according to Geiger et al. (2010), practices using intensively insecticides and fungicides reduce the provision of ecosystem services, due to the reduction in biodiversity.

However, there may be other reasons justifying this nondifference in the sale price of agricultural land. Indeed, if we look at the supply of organic land, we can see two issues, the low supply compared to conventional land and their inappropriate geographical positioning. In fact, only 11.7% of the agricultural land is farmed organically in 2020. Moreover, these lands are exploited by farmers who are 5 years younger on average (51 years old against 56 in CF). Knowing that the main cause of land sales is retirement, it explains why organic land for sale is scarcer because it is not yet available. To measure the extent of the low organic supply, we calculated the minimum distance between an organic farm and an organic land for sale, as well as, between an organic farm and a conventional land for sale. We did this from the database of land sales used in the article, in which we include the geographical location of all organic farmers (database produced by the French Organic Agency). It appears that the average minimum distance from an OF to an organic land for sale is 12.8km compared to 5.9km from a conventional land for sale (significantly different, by Student's t test with a margin of error of 0.1%). Knowing this, it would be interesting to know if an OF has more interest in buying an already organic land far away rather than converting a conventional land closer. Indeed, the price of the two lands being equal, only the transport costs explain the difference

6. Conclusion

In conclusion, it appears that the economic situation between OF and CF is quite similar. Indeed, the land is valued in the same way and farmers' incomes are similar. Therefore, the current economic incentive to convert to OF is weak or even non-existent, since the economic situation does not differ between the two states, whereas the farmer must go through 2 or 3 years of conversion during which he will lose income.

In order to tackle this situation, it would be interesting to set up a land market exclusively for organic farmland. Ideally, prices in this new market should be higher than prices for conventional land, thus improving the economic situation of OF by sending a signal to CF. Non-converting farmers would be more motivated to convert if they saw the possibility to increase the value of their land by selling organic land. Moreover, the higher price applied to organic land seems justified. Indeed, the environmental quality of organic land is superior to that of conventional land (for Sautereau and Benoit (2016), Underwood et al. (2011)), notably because of the greater quantity of ecosystem services. Nevertheless, given the results on the organic land supply seen of the discussion, the recommendation cannot be so simplistic. An extensive study of the land market with forecasts of the future evolution of this market seems to be important to set up.

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7. Appendix

Appendix 1: Data source

Table 4: Descriptive statistics of the variables

Variable	Definition	Source
Av temperature	Average temperature each season between 1979 and 2020, 25km Grid	European Joint Research Center
Av precipitation	Average precipitation each season between 1979 and 2020, 25km Grid	European Joint Research Center
Elevation	Elevation of the land sold	INSEE
Org sale	Land under organic farming at the time of sale	DVF and RPG
Urban index classification	Classification for French municipality regarding number of jobs	INSEE
Artificialisation growth	Share of the municipality's surface area that has changed from natural to urbanized	French Artificialisation Observatory
Population Growth	Population growth in the french municipality during 2012 and 2017	INSEE

7.1. Appendix 2: Product selected in yield and price analysis

- Cereal: Wheat, Rye, Spring/winter barley, Oats, Summer cereal mix, Maize, Triticale, Lucerne, Sunflower, Other cereals
- Fruit: Tomato, Strawberry, Apple, Apricot, Melon
- Roots and tubers: Potato, Bean, Lentil, Pea, Soy
- Vegetables: Carrot, Cabbage, Onion, Salad, Courgette

Relative to CF	Min Yield	Max Yield	Min Price	Max Price
Vegetables	0.59	1	1.29	1.97
	(Courgette)	(carrot, Cabbage, Onion, Salad)	(Onion)	(Salad)
Roots and tubers	0.57	1	1.32	1.49
	(Bean)	(Potato, Lentil, Soy)	(Soy)	(Bean)
Fruit	0.36	1	1	1.43
	(Apricot)	(Strawberry)	(Strawberry)	(Tomato)
Cereal	0.37	1	1	1.62
	(Spring barley)	(Other cereals)	(Sunflower)	(Spring barley)

Table 5: Comparative yield and price between OF and CF by crops