Ecological agriculture and return to skills: A comparison between France and the UK

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Abstract

This paper investigates skill requirements and return to skills in a range of farming techniques contributing toward ecological agriculture. The study focuses on specific case study regions in France and the UK. Methodological approach includes two stages. In the first stage the requirements to skills are estimated depending on the degree of implementation of ecological farming practices in a farm, and in the second stage the estimated skill proxies are used to estimate the outcome - returns to skills. The unique data set employed was collected in 2019-2020 through a farmers' survey designed specifically to gather information on the economic, environmental and social impact of ecological techniques. The results show a stark contrast between the two countries which might reflect differences in the educational systems. In France, general education and agricultural education have a negative effect on the probability to adopt ecological agriculture, whilst the effect in the UK is positive. Similarly, skill level enables higher returns in the UK, but its effect in France is negative.

Key words: skill requirements, return to skills, ecological technology, France, UK

Acknowledgements

This paper is part of the LIFT project ('Low-Input Farming and Territories – Integrating knowledge for improving ecosystem-based farming') that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 770747. The authors are grateful to persons who helped in the implementation of the farmers' and stakeholders' surveys.

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1. Introduction

The adoption of new techniques or technologies of production and their effective employment requires skill - skill in the selection of the most appropriate technologies, in the adaptation, interpretation and implementation of the technologies into the wider systems of production in a given context and ultimately to employ these skills for economic gain. We expect that the complexity of farm systems, relying, as they do, on unreliable nature, which produce a wide range of outputs and operate in environments that are difficult to monitor in real time, would require broad skill sets.

The objective of the paper is to analyse the skill requirements and return to skill in a range of farming techniques which contribute toward ecological agriculture/regenerative farming, including techniques employed in organic farm systems. Skills are required not only for the adoption of these techniques, but also for their adaptation to a specific agro-ecosystem, to specific soil types and climatic conditions.

Little research has been carried out on the effect of farming techniques contributing toward ecological agriculture on farm labour. What has been done so far has mainly focused on organic farming. Analyses in these studies tried to reveal the effects on labour demand/use, e.g. whether organic farming requires more labour (e.g. Gardebroek *et al*., 2010; Kumbhakar *et al*., 2009; Zhenkfei *et al*., 2005). However, not only the quantity of labour demand in different farming techniques is important, but also the requirements toward the quality of labour.

One of the main reasons for the gap in research in relation to skills required in ecological farming techniques is the lack of adequate data. This paper is based on a unique dataset collected through a farmers' survey in some regions in France and the UK (two in each country). The survey was designed with the objective to produce insights into the economic, environmental and social impact of ecological approaches to farming. It has collected detailed information on the application of different farming techniques. One of the parts in the survey was particularly targeted at on-farm labour and it provides a useful basis for the empirical analysis in this paper.

A two-stage methodological approach is employed. In the first stage the requirements to skills are estimated depending on the degree of 'ecological technique adoption' on a farm (i.e. a demand side approach). The estimated skill proxies are used in the second stage to estimate the return to ecological innovation skills, the outcome.

The results show a stark contrast between the two countries which might reflect differences in the educational systems. In France, general education has a negative effect on the probability to adopt ecological agriculture, whilst the effect in the UK is positive (agricultural education also has a negative effect in France but positive in the UK). Similarly, skill level enables higher return to skill in the UK, but its effect in France is negative. The results raise issues about the extent to which the traditional educational system can prepare farm labour for adoption of new techniques and their efficient exploitation.

The paper is organised as follows. The next section provides a background to our empirical study with a literature review and prior qualitative research. The third section describes the case study areas in France and the UK. The fourth section explains the methodology and data. The fifth section presents the results and the last section concludes.

2. Background

2.1. Literature review

One of the problems of empirical analysis of the effects of techniques that lead toward ecological agriculture on return to skills is that ecological agriculture is a very broad concept, incorporating a mix of more traditional and more recent environmentally friendly farm practices. Also, internationally, there is not a common definition or a standard certification process as, for example, the one that is in place for organic products and, as a consequence, there is a lack of relevant statistical information. As a result, the bulk of studies on ecological farming include mainly broad discourse and do not attempt more rigorous quantitative analyses.

Therefore, it is not surprising that there is little previous research to inform the analysis in the present paper. Mills (2012) looked at the social benefits of agri-environmental schemes (AESs) beyond the targeted environmental gains. The data for the analysis was collected through 360 interviews with environment schemes agreement holders out of which 288 were telephone interviews and the remaining face-to-face. The study compared the effect on workload and development of human capital by two AESs implemented in England, the Entry Level Stewardship Scheme and Higher-Level Stewardship Scheme, the latter being a more challenging one. The results indicated that the participation in AESs contributed to human capital, i.e. increasing farmers' skills to farm more sustainably.

Marinoudi *et al*. (2019) employing a framework of skill biased technological change investigated the effect of automation and robots on skill sets in agriculture and underlined three major changes: first, whilst in the past labour was basically focused on completing manual tasks, labour and technology were assumed to be perfect substitutes since technology for cognitive tasks was not considered. Currently, most of the jobs are complex since the modern work processes require a set of various inputs of different aptitudes and skills, and each one of these labour inputs play an essential and non-replaceable role. Second, concerning automation in agriculture, there is a complementarity between labour and machines, e.g. a human operator is required to offset the shortcomings of the robot's intelligence to cope with unpredictable events. Third, on the other hand, modern technology has also the opposite effect, i.e. it often reduces the requirements for human skills, e.g. the implementation of autosteering and navigation-aiding systems for agricultural machinery. Overall, the authors argue that new technologies may lead to polarisation of skill requirements and thus the wages. When the automation level increases there are increased requirements in terms of skills and education from the workers who complement the introduction of new technologies, and on the other hand, there is still a demand for low-skilled labour for the execution of the residual activities in routine tasks. This narrows down the demand for and use of middle-skilled labour.

Concerning organic farming, Navarrete *et al*. (2015) looked at organic horticulture farms which they divided into four categories: specialised and small; specialised and large; diversified and small; diversified and large. The authors found that diversified farms required more labour per hectare as this method is generally more complex due to different crop requirements and plot agronomical constraints. Since the production process is more complex, the farmers also required more specific skills.

However, not all the studies supported that the participation in AES or in organic farming requires different/higher skills in participating farmers. For example, often farmers participate in AES schemes because of a combination of business interest to capture the attractive agri-environmental payments and because the schemes required very small adaptations of existing farming practices or no change at all (Harrison *et al*. 1998; Wilson and Hart 2000; Schmitzberger et al. 2005; Lobley *et al*., 2013). Burton *et al*. (2008) argue that skills were necessary at the stage of setting the AES, e.g. to make decisions which land to allocate for AES or how to maximise subsidies. However, after that initial stage, in the implementation process there were not particular skill requirements since farmers simply had to follow the prescribed practices of a particular scheme, and this often constraints the development of farmers abilities to develop and implement innovative ideas in conservation agriculture.

Based on the review above, it appears that the effect of ecological farming practices on rewards to skills is to a great extent an empirical issue since these practices may require additional skills or may only involve strict compliance with AES prescriptions. In order to build some prior expectations, we carried out qualitative research in the case study regions using Delphi method.

2.2. Preliminary qualitative research: Delphi method

The Delphi method attempts, first, to collect the views and opinions of a number of informed people and, second, to harmonise these views across a panel of experts (Borjeson, et al., 2006). Gallego and Bueno (2014) define Delphi as a type of questionnaire, which, through feedback, organises and shares opinions. According to the authors there are four main characteristics of Delphi. First, it is anonymous (each stakeholder does not know the response of another). Second, it iterates through rounds of sharing opinion and feedback. Third, controlled feedback is given (responses are summarised by researchers and presented again to the stakeholders). Fourth, a group response is produced statistically.

Delphi was implemented in the French and UK case study regions, the same regions in which farmers' survey data used in the econometric analysis was collected. Approximately 10 stakeholders were involved in each region in the Delphi analysis. The objective was to have a balanced representation by years of experience and occupation – advisory system officers, researchers, land agents, farmers, civil servants, non-government organisation representatives.

As a first step we provided a representative model of a typical ecological farm in each of the case study regions and asked the stakeholders to describe the changes in the farming practices they foresee in comparison to a typical conventional farm in their area. A scenario of a hypothetical pattern of adoption (including high, low, clustered, random pattern) has been suggested to the respondents and they had to choose the pattern they expected to be the most probable for their region. Second, the participants were asked about their opinion on what might happen in factor markets, especially considering whether there would be any second-round effects on the labour market. Third, we summarised these opinions and presented them again to the stakeholders, asking them if there were any revisions to be made. Finally, we looked for signs of convergence and consensus.

After this first step, three rounds of Delphi were implemented. In the first round participants were asked to characterise ecological approaches to agriculture as they may develop in 10-year time in their region; the second round enquired about the socioeconomic effects of these ecological approaches and the third round repeated the questions of round 2 presenting a summary of round 2 to participants.

Concerning the development of farming practices, respondents tended towards the proliferation of ecological farming but in parallel with the continuous existence of conventional agriculture. Concerning skills, Delphi participants argued that modern farmers are highly skilled, but to be able to adopt more environmentally friendly practices they may need to further develop their skill sets. Three main points were emphasised for skill demand.

First, ecological agriculture might result in integrating multiple farming systems onto a single farm: crops, livestock, orchards, forestry. These farms would be more complex operations requiring a variety of skills and knowledge. The larger set of skills would require a versatile farmer with a wide range of skills or workers covering the necessary range, which might result in more hired labour, particularly on larger farms.

Second, in order to provide more public goods and ecosystem services, farmers have to adopt different practices: intercropping, cover and catch cropping, holistic planned grazing, Integrated pest management, Integrated weed management. These practices require an increased understanding of biology, ecosystems and natural processes. Observation skills, and not so much the traditional repetitive manual work, would be necessary for recognising e.g.

pest species from beneficial species. However, some stakeholders argued that the new requirements can be handled through contracting an adviser on bigger farming operations.

Third, adoption of more ecological farming practices requires knowledge of its possible impacts on soil, water, air, and skills to market the positive effects to the buyers of farm produce. Knowledge will be necessary to use the public incentives and comply with regulations with respect to public good and ecosystem service provision, and how environment management can be integrated with the farming operation. Stakeholders argued that farmers have to learn on the job, be proactive and stay informed regarding developments in the industry and should actively communicate with other farmers.

Results from Delphi in the case study regions under analysis here have indicated consensus that farmers would need new skills to operate a farm adopting ecological farming techniques. However, similarly to the views covered in the literature review above, some stakeholders, although a minority, suggested that new technologies, irrespective to whether they are related to ecological farming or not, e.g. precision farming, robots, AI, may limit the requirements to skills and decision making by farmers.

Overall, the results from Delphi suggest that we may expect a need for more skills in order to successfully adopt ecological approaches to farming. However, caution is necessary since consensus has not been reached in Delphi. And, in any case, the main gap in the literature, and in our Delphi exercise, remains whether the skill sets necessary for ecological farming differ from those needed for more conventional agriculture and what would be the effect on the return to such skills.

3. Short overview of case study regions

3.1. French case study

This study is implemented in two areas in France, namely NUST2 regions Brittany (in Western France) and Auvergne (in Central France)[4]. Brittany region is quite densely populated (109 inhabitants/km² compared to 57 inhabitants/km² for the French average) and unemployment is low (only 8.4% in 2010 compared to 10.2% nationally). The utilised agricultural area (UAA) in this region represents 62% of the whole regional area (50% at the national level). Brittany is the most important region in terms of agricultural production, particularly for fresh vegetables (83% of cauliflower production) and animal production (58% of pigs, 42% of laying hens, 21% dairy cows). The agri-food industry accounts for around a third of industrial jobs in the region (around 68,000), i.e. 6.51% of total number of jobs in the region (compared to 2.44% in France). Brittany has 32,150 farms but between 2000 and 2010 the number of farms decreased by 32%, thus with a higher rate than in metropolitan France (26%).

As for Auvergne region, it ranks 19th in terms of regional population and is divided between mountainous areas, fragmented forest areas, and the Limagne plains. The primary sector is of low importance in terms of employment (only 2% in 2018) compared to the tertiary sector (representing 34.5% of employment, vs. 30.6% at national level). Rural areas represent 69% of the overall regional area, although agricultural productivity is rather low and located mainly in less favoured areas (13,158 Euros per AWU in Auvergne vs. 36,894 Euros per AWU at national level). The agri-food sector represents 2.7% of regional jobs, mainly in the dairy and meat sectors (6 jobs out of 10). Most farms (70%) are located in mountainous areas and

[4] 'The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU and the UK' (https://ec.europa.eu/eurostat/web/nuts/background)

approximately 75% of the farms are specialised in grazing livestock. Farms in Auvergne are significantly larger than the French average (62 ha compared to 56 ha in 2010). Similar to the national trend, the population of active farmers is ageing (only 10% of farmers are under 35 years old) and declining. In addition, the average income received by a farmer is lower than at national level: 22,000 Euros per year per AWU vs. 30,000 Euros for France.

Regarding the rural development plans, within the 2014-2020 CAP programming period covering this study, France chose to design and implement the rural development policy at regional (NUTS2) level, in order to stick as much as possible to local contexts and specific environmental or social issues. In the Auvergne region, AESs mostly concerned (i) the compensatory allowance for permanent natural handicaps, (ii) organic farming and (iii) local AESs mostly oriented towards eco-friendly management of grasslands (e.g. reduced or no fertilization, low animal pressure on grazing areas, common grazing practices). In Brittany, the focus was placed on schemes that helped regaining water and soil quality, and on schemes targeting biodiversity. As far as grazing livestock farming was concerned, this was reflected in the design and the implementation of grassland-based system AESs (mainly substituting grass for maize silage), in local AESs targeting wetlands and landscape features, and conversion to organic farming.

3.2. UK case study

Both case study areas are located in South East England – the most populous region in the UK with approximately 9.2m inhabitants, 13.7% of the UK total, and very densely populated at 481 inhabitants/km² against a UK average of 275 inhabitants/km² (ONS, 2020a). Unemployment in the region in 2019 was equal to 3.2% which was slightly below the UK average of 3.9% (ONS, 2020b).

The case study area of North Kent includes a number of National Character Areas (Natural England, 2014) and this is an area of diverse agricultural systems, with a mix of livestock, horticulture and arable farms. The North Kent Plains contain fertile loam soils thus being characterised by arable, traditional orchards, and soft fruits and vegetables. Grazing marsh in typical the Great Thames Estuary and mixed farming is widespread on the North Downs.

In contrast, the other case study area in the High Weald is a home predominantly of pastoral agriculture with areas of horticulture on higher ground, while the low lying, flat areas towards the east contain concentrations of arable farmland. This landscape was granted Area of Outstanding National Beauty status in 1983, recognising the unique High Weald landscape of a mosaic of small farms, the highest concentration of woodland, in England (26%) and ridge-top villages.

Farms are on average larger in the North Kent study area, 96.8 ha, in comparison with 53.1 ha in the High Weald (DEFRA, 2016) and the total farmed area is larger in North Kent (157,340 ha against 97,937 ha in the High Weald). This is not surprising bearing in mind that a large proportion of farms in the High Weald tend towards the smaller end of the scale (47% less than 20 ha versus 43% in North Kent) while there are a significant number of farms in North Kent larger than 100 ha (25% versus 14% in the High Weald). Compared to the High Weald, North Kent has a far larger proportion of cereal[5] farms (26% against 10%), but a much lower importance of grazing livestock (30% against 53%).

[5] Farm types are classified using standard output, percentages are authors' own calculations.

4. Methodology and data

4.1. Methodological approach

Our starting assumption in this research is that successful adoption of novel technology, and especially in the setting of ecological farming, is dependent on skills, in particular, those skills needed to understand new methods of production and how to innovate and adapt those methods to local environments.

Few, if any, survey data set will directly record the skill of a decision maker, let alone other family and hired farm employees, and it is difficult to think of a survey question that could elicit a meaningful measure to capture the level of skill available within a farm or firm. The data we employ here is no exception. However, it is not uncommon for business surveys to include variables on both the level of education attained by the key decision makers in the business and other variables, including age or experience within the wider production system for example. In our case, we use data records of the highest level of education attained by the decision maker and other family workers, whether that education was specific to farming or not, and the number of years of their on-farm experience.

Faced with a situation where the variable we are most interested in is unobserved, our empirical strategy takes two steps. In the first of these steps we estimate an equation to explain the adoption of key ecological agriculture practices on farms using the farm experience, level of education and the specificity of that education, i.e. agricultural or not, the decision maker and working family members on the farm, as shown by equation (1).

$$T_f = \beta_0 + \beta_1 Exp_f + \beta_2 Exp_f^2 + \beta_3 Edu\_level_f + \beta_4 Edu\_agri_f + \epsilon_f \quad (1)$$

where T_f is a categorical variable representing the degree of use of ecological practices in each individual farm; Exp_f and Exp_f^2 are respectively the number of years of farm experience available on the farm and the square of this number; Edu_level_f is the level of general education on the farm; Edu_agri_f is the level of agricultural education on the farm; $\beta_{0,\ldots,4}$ are parameters to be estimated ; and ϵ_f is an error term. A farmer is computed as having a general education if they have received a high-school, college or university education in non-agricultural studies, whereas farmers with an agricultural education have studied an agricultural course at college or university.

Equation (1) allows an investigation of whether higher levels of human capital endowment on a farm permit or promote a greater degree of ecological technique adoption. That is, whether education and experience play a part in developing innovative capacity on the farm.

Education of the decision maker and family workers, whether formal agricultural education and/or general education, is an investment in human capital, and as such are shown to have a positive influence on ecological sustainability (Suess-Reyes & Fuetsch, 2016). Human capital acquired through experience, may have a positive impact on the adoption of ecological techniques, but it is strongly correlated with age. Suess-Reyes & Fuetsch (2016) argue that a farm's sustainability decreases with farmer's age as older farmers tend to follow traditional approaches; we include Exp_f^2 to control for this life cycle effect.

Fitted values from equation (1) are used to represent a farm's innovative capacity. We assume that these fitted values represent an approximation for skills held by a farm which are of particular value in the selection, innovation and application of novel ecological technologies. In the second stage of our empirical strategy, we include these fitted values as skill proxies in equation (2) designed to estimate the return to skill:

$$\frac{R_f}{L_f} = \delta_0 + \delta_1 \widehat{T_f} + \delta_2 L_f + \delta_3 K_f + \delta_4 C_f + \omega_f \qquad (2)$$

where $\widehat{T_f}$ is the fitted value from equation (1); R_f is a measure of either farm revenue as used in the UK (revenue here comprises revenue from crop, livestock and agricultural products as well as agri-environmental subsidies), or turnover as used in France (revenue excluding subsidies), the latter chosen due to the data availability; L_f is the quantity of farm labour measured in hours, and the revenue share of labour, i.e. the ratio $\frac{R_f}{L_f}$, is used as a proxy for wage (return to skill) with the expectation that, as the number of additional hours worked increases, the hourly wage will fall slightly; K_f is farm capital, which is expected to enhance return to labour; C_f are other control variables, e.g. case study area, farm type; $\delta_{0,\ldots,4}$ are parameters to be estimated; and ω_f is an error term.

4.2. Data

The data used here were collected through face-to-face interviews during autumn 2019 and spring 2020, and relate to the year 2018. Farmers' contacts were obtained from farm advisory services or processors. The survey collected detailed information on the use of farming practices and on farm labour force, which is not available in widely-used economic databases. The sample consists of 55 farms in the UK case study and 159 farms in the French one. The French farms include specialist dairy, specialist beef and mixed livestock farms - a mix of dairy and beef cattle. The UK sample covers a wider range of farm types which reflects the varied agricultural landscape in the case study areas (Table 1).

Table 1: Farms' production specialisation in the sample used

	Number of farms in France case study	**Number of farms in UK case study**
Dairy farms	108	3
Cattle farms	42	11
Mixed livestock farms	9	4
Field crop farms		15

Horticulture farms Mixed crops and livestock farms Sheep farms		9 10 3
All farms	159	55

4.3. Empirical strategy

Estimations have been carried out separately for the French sub-sample and the UK one in particular because of the difference of definition in some variables. Several attempts have been made to define the degree of implementation of ecological practices in each farm, T_f. One attempt was to construct it as a count of ecological technologies, similar to the count data models of Sharma *et al*. (2011). For example, T_f for crop farms may count the farm's adoption of some techniques as integrated pest management, precision technology, integrated weed management and conservation tillage. Similarly, for livestock T_f count could include the non-use of concentrates, and medicines for prevention and for treatment of livestock, and then combine crop and livestock in mixed farms according to their revenue share in output. Other attempts were to create a binary measure, e.g. T_f to take the value 1 if the farm is organic and 0 if not; 1 if the farm uses conservation tillage 0 if not, etc. However, all these attempts may miss the range of practices contributing to ecological farming implemented by some farmers. For this reason, the choice was to include a summative indicator, i.e. the receipt of agri-environmental payments (AEP) as a compensation for the increased costs of participation in AES, and/or engagement in organic farming. Both indicators are adequate to define the ecological practices since organic certification is only based on practices (not on results) and AES are also designed only on practices (again not on results). Additionally, in England, AES are considered as the single most important tool for managing many components of England's ecological network (Lauton *et al*., 2010). In France the AES support farmers willing to implement practices having an impact on both economic and environmental performance. New schemes were designed in the 2014-2020 period focused on the agricultural system level.

In view of the above considerations and allowing for identical construction of T_f in France and the UK, T_f has been constructed as a binary variable which takes the value 1 if, in 2018, the farm was certified organic or was engaged in any AES, and 0 otherwise. The first-step equation (1) has been estimated as a Probit model - this first-step estimates the probability of a farm adopting the ecological technology given its underlying level of human capital.

Farm experience (Exp_f) is proxied by the average years of on-farm experience of family members working on the farm. Farm general education (Edu_level_f) is proxied by a dummy variable taking the value one if at least one of the family members working on the farm has a high school or university level of general education, and 0 otherwise. The proxy for agricultural education (Edu_agri_f) is constructed in a similar way as general education, only concerning an agricultural course at high school and/or university.

As indicated previously, to proxy the return to skill in the second-stage equation, R_f is measured as farm turnover in the French sub-sample, while it is farm revenue in the regression on the UK sub-sample. The choice was made due to data availability (more farmers in France provided data on the turnover, whilst in the UK on the revenue). For both sub-samples, L_f is the total number of worked hours on the farm, both from family and hired labour. In the UK sub-sample capital (K_f) is proxied by the average asset value of farm's agricultural buildings and machinery. As this information was available only for a small number of farms in the French sub-sample, capital is proxied by the size of cattle herd, measured in livestock units. Since all farms in the French sub-sample are specialised in livestock, it has been assumed that the cattle herd size might be proportional to the level of capital. To complement this capital proxy, the estimations on French sub-sample used the UAA as well. Finally, a regional dummy has been included as a control variable (C_f). In the French sub-sample, it takes the value one if a farm is located in Auvergne region, while in the UK sub-sample it takes the value one for farms located in the High Weald. A farm specialisation dummy, taking the value one for farms specialists in dairy and zero otherwise has been included for France, while in the UK sub-sample the dummy is for field crops.

Table 2 provides descriptive statistics of the two sub-samples used. The UK sub-sample has a smaller share of organic farms (this share reflects approximately the national share of organic farms), but more farms participating in AES than in the French sub-sample. Farm experience and agricultural education are slightly higher in the French sub-sample, whilst general education is higher in the UK. Labour hours are higher on UK farms which could be expected as there are nine horticultural farms in the sample involving a high share of hired labour, including seasonal workers. The UK farms are also highly capitalised reflecting the bigger machinery that tend to be needed on cereal farms in contrast to livestock farms populating the French sub-sample. Average revenue is also higher on the UK farms, one of the reason being that subsidies are not included in the French proxy.

Table 2: Descriptive statistics of the sample used

	Descriptive statistics for the French sub-sample			Descriptive statistics for the UK sub-sample		
	Number of observations	**Mean or share of farms (%)**	**Standard deviation**	**Number of observations**	**Mean or share of farms (%)**	**Standard deviation**
Share of farms with ecological technology ($T_f = 1$)	159	49%		55	62%	
Share of farms with organic farming	159	18%		55	9%	
Share of farms with AESs other than organic farming	159	21%		55	53%	
Farm experience proxy (Exp_f) (years)	155	23.5	8.91	55	36.62	13.34
General education proxy (Edu_level_f) (dummy)	154	0.17	0.38	55	0.35	0.48
Agricultural education proxy (Edu_agri_f) (dummy)	154	0.87	0.34	55	0.82	0.39
Farm total labour (L_f) (hours)	146	6,453	3,290	55	9,244	12,829
Share of farm total labour from hired workers (%)	146	8	15	55	38	32
Farm capital value (K_f) (Euros)	60	630,194	1,071,163	44	1,514,714	2,040,475
Farm cattle herd size (K_f) (livestock units)	159	98.64	59.12	55		
Farm UAA (K_f) (ha)	158	114.93	72.62	55	298.17	366.07
Farm turnover (R_f) (France) or revenue (UK) (Euros)	121	260,102	246,996	55	662,351	953,982.1
Return to labour (R_f/L_f) (Euros/ hour)	111	44.51	32.53	55	74.73	85.2948
Dairy(FR)/field crop(UK) specialist dummy (C_f)	159	0.68	0.47	55	0.27	0.45
Regional dummy (C_f)	159	0.44	0.50	55	0.38	0.49

5. Results

Table 3 displays the results from the first-step equation (1) with the ecological technology dummy as dependent variable. Results indicate that farm experience has no significant impact on the probability to use the ecological technology.

As it could be expected a high level of general education increases the probability of using the ecological technology for the UK sub-sample, as well as agricultural education but the latter with lower level of significance. By contrast, the impact of both educations are negative in France, in line with the results obtained by Le Coent *et al*. (2021). In the literature, there is contradictory evidence concerning the effect of education on AES contracting in France. Chabbé-Ferret and Subervie (2013) found that participants are more educated from non-participants, using data from the 2000 French Agricultural Census. In contrast, Dakpo *et al*. (2021) on dairy farms in the French FADN dataset in the period 2002-2016, found that low education (measured as a dummy taking the value one if none or low education, and zero if high education) increases the probability to be AES participant. The farms in the sub-sample used in this paper are relatively large and commercial – similar to those included in FADN. Therefore, our results corroborate the results of Dakpo *et al*. (2021) that higher education does not increase the probability to participate in AES.

Table 4 shows results from the second-step equation (2) with the revenue per work hour as dependent variable, a proxy for wage, and the fitted value from equation (1) as an explanatory variable measuring the capacity of a farm to innovate into an ecological technology using its level of human capital. Results indicate that this skill proxy is positive in the regression on the UK sub-sample, suggesting that this skill level enables a higher return to labour. By contrast, the fitted value is negative in the regression on the French sub-sample, revealing that the skills used to implement the ecological technology may not be appropriate for this technology and result in loss. This may come from the fact that both high general education and agricultural education have a negative impact on ecological technology use in the first-step regression for the French sub-sample. Other (unobserved) variables may explain the skills needed for this technology such as specific training or courses

As expected the quantity of labour on farm has a negative impact on the return to labour, while assets (capital value, herd, land) have a positive impact. The regional dummy is significant in the French sub-sample regression, indicating that livestock farms in Brittany perform better than their Auvergne counterpart in terms of return to labour.

Table 3: Results from the first-step equation (1) with the ecological technology dummy as dependent variable

	Results for the French sub-sample	**Results for the UK sub-sample**
Farm experience (Exp_f)	0.025 (0.045)	0.000 (0.064)
Farm experience squared (Exp_f^2)	-0.000 (0.001)	0.000 (0.001)
General education (Edu_level_f)	-0.613 ** (0.309)	1.072** (0.501)
Agricultural education (Edu_agri_f)	-0.887 ** (0.354)	0.913* (0.551)
Intercept	0.430 (0.632)	0.154 (0.423)
Pseudo R-square	0.049	0.094
Number of observations	152	55

Note: Estimated coefficients with standard errors in brackets. *, **, *** indicate significance at the 10%, 5%, 1% level respectively.

Table 4: Results from the second-step equation (2) with the return to labour as dependent variable

	Results for the French sub-sample	**Results for the UK sub-sample**
Fitted value from first-step equation ($\widehat{T_f}$)	-51.510 ** (23.020)	100.844** (45.124)
Farm total labour (L_f)	-0.003 *** (0.001)	-0.002** (0.001)
Farm capital value (K_f)	-	0.00002*** (0.000)
Farm cattle herd size (K_f)	0.172 *** (0.046)	-
Farm UAA (K_f)	0.058 * (0.035)	-
Regional dummy (C_f)	-21.400 *** (6.308)	-13.445 (14.911)
Field crop specialist dummy (C_f)	-	67.079*** (16.785)
Dairy specialist dummy (C_f)	4.219 (6.498)	-
Intercept	71.183 *** (14.897)	-21.923 (26.498)
Pseudo R-square	0.391	0.618
Number of observations	107	44

Note: Estimated coefficients with standard errors in brackets. *, **, *** indicate significance at the 10%, 5%, 1% level respectively.

6. Conclusions

To the best of our knowledge, this is a first paper which tries to address the return to skills in ecological agriculture. This is due to a great extent to a lack of specially targeted data on the adoption of ecological farming practices by farmers. The initial hypothesis of this paper is that the adoption of new techniques or technologies of production and their effective employment require skills which underpin the innovative capacity of a farm, and that these skills should influence the labour share of revenue. Unique data from a farmers' survey focused on ecological farming practices in two countries – France and the UK – is analysed. Methodological approach includes two stages: in the first stage the requirements to skills are estimated depending on the degree of implementation of ecological farming practices in a farm, and in the second stage the estimated skill proxies are used to estimate the outcome - return to skills.

The data refers to 2018, a year when both countries France and the UK were EU Members, although farmers in the UK would have been preparing for some, yet to be confirmed, form of Brexit. However, to the extent that AES are concerned, EU Members have flexibility to design schemes that suit best their environmental conditions and citizens preferences. Additionally, each EU Member State has national education policy. Therefore, it is not surprising that the results indicate a stark contrast in the contribution of education and skills to farm capacity to adopt new farming practices. In France, general education and agricultural education has a negative effect on the probability to adopt ecological agriculture, whilst the effect in the UK is positive. Similarly, skill level enables higher return in the UK, but its effect in France is negative.

This can potentially be explained by agricultural courses in France being predominantly conventional, at least in the time that the sample farmers would have been attending colleges and universities. Another reason that may explain the discrepancy between French and UK results lies on the definition of the return variable. Due to data availability, the return for the UK sub-sample includes all revenue - from sales and subsidies, while the return variable for the French sub-sample includes only turnover, that is to say that subsidies are not included. Thus, while the French results capture the link between skills and return from production activities, the UK results may in fact show the skills required to obtain subsidies, e.g. from AES. Another difference between the French and UK specification is the production specialisation of the farms. While the UK sub-sample is relatively diverse, the French sub-sample includes only farms breeding mainly cattle. In this type of farming, farmers with high education may prefer to produce intensively instead of reorganising their farms to comply with organic or AES requirements. Further research may disentangle the different practices covered by organic certification and AES, and assess whether the effects found above are also found for separate practices.

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