LIFT

Low-Input Farming and Territories – Integrating knowledge for improving ecosystem based farming

Research and Innovation action: H2020 – 770747
Call: H2020-SFS-2016-2017
Type of action: Research and Innovation Action (RIA)
Work programme topic: SFS-29-2017
Duration of the project: 01 May 2018 – 30 April 2022

Employment effects of ecological farming at the farm level

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DELIVERABLE D3.4

Workpackage N°3

Due date: M38

Actual delivery date: 30/06/2021

Dissemination level: Public

About the LIFT research project

Ecological approaches to farming practices are gaining interest across Europe. As this interest grows there is a pressing need to assess the potential contributions these practices may make, the contexts in which they function and their attractiveness to farmers as potential adopters. In particular, ecological agriculture must be assessed against the aim of promoting the improved performance and sustainability of farms, rural environment, rural societies and economies, together.

The overall goal of LIFT is to identify the potential benefits of the adoption of ecological farming in the European Union (EU) and to understand how socio-economic and policy factors impact the adoption, performance and sustainability of ecological farming at various scales, from the level of the single farm to that of a territory.

To meet this goal, LIFT will assess the determinants of adoption of ecological approaches, and evaluate the performance and overall sustainability of these approaches in comparison to more conventional agriculture across a range of farm systems and geographic scales. LIFT will also develop new private arrangements and policy instruments that could improve the adoption and subsequent performance and sustainability of the rural nexus. For this, LIFT will suggest an innovative framework for multi-scale sustainability assessment aimed at identifying critical paths toward the adoption of ecological approaches to enhance public goods and ecosystem services delivery. This will be achieved through the integration of transdisciplinary scientific knowledge and stakeholder expertise to co-develop innovative decision-support tools.

The project will inform and support EU priorities relating to agriculture and the environment in order to promote the performance and sustainability of the combined rural system. At least 30 case studies will be performed in order to reflect the enormous variety in the socio-economic and bio-physical conditions for agriculture across the EU.

Project consortium

No.	Participant organisation name	Country
1	**INRAE - Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement**	**FR**
2	VetAgro Sup – Institut d'enseignement supérieur et de recherche en alimentation, santé animale, sciences agronomiques et de l'environnement	FR
3	SRUC – Scotland's Rural College	UK
4	Teagasc – Agriculture and Food Development Authority	IE
5	KU Leuven – Katholieke Universiteit Leuven	BE
6	SLU – Sveriges Lantbruksuniversitet	SE
7	UNIBO – Alma Mater Studiorum – Universita di Bologna	IT
8	BOKU – Universitaet fuer Bodenkultur Wien	AT
9	UBO – Rheinische Friedrich-Wilhelms – Universitat Bonn	DE
10	JRC – Joint Research Centre – European Commission	BE
11	IAE-AR – Institute of Agricultural Economics	RO
12	MTA KRTK – Magyar Tudományos Akadémia Közgazdaság – és Regionális Tudományi Kutatóközpont	HU
13	IRWiR PAN – Instytut Rozwoju Wsi i Rolnictwa Polskiej Akademii Nauk	PL
14	DEMETER – Hellinikos Georgikos Organismos – DIMITRA	GR
15	UNIKENT – University of Kent	UK
16	IT – INRAE Transfert S.A.	FR
17	ECOZEPT Deutschland	DE

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List of acronyms and abbreviations

AI	Artificial Intelligence
AEP	Agri-Environmental Payments
AES(s)	Agri-Environment Scheme(s)
AWU	Annual Work Unit
CA	Conservation Agriculture
CAP	Common Agricultural Policy
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DOOR	Database of Origin and Registration
ES	Ecosystem Services
EZ(s)	Enterprise Zone(s)
EU	European Union
FADN	Farm Accountancy Data Network
FTE(s)	Full Time Equivalent(s)
GDP	Gross Domestic Product
GI	Geographical Indication
ha	Hectares
HUF	Hungarian Forint
km^2	square kilometre
KRUS	Agricultural Social Insurance Fund (Polish)
MS(s)	Member State(s)
MSA	Mutualité Sociale Agricole (French)
NMS(s)	New Member State(s)
NUTS	Nomenclature of Territorial Units for Statistics
ONS	Office for National Statistics
PDO	Protected Designation of Origin
PG	Public Goods
PGI	Protected Geographical Indication
SE	Simplified Employment
SOLID	Sustainable Organic and Low-Input Dairying
UAA	Utilised Agricultural Area
UK	United Kingdom
US	United States
ZRR	Zones de revitalisation rurale (French)

1 Summary

This deliverable investigates the employment effects of ecological farming by analysing both the differences in the intensity of labour use and rewards to skills. It contributes to one of the main outcomes/achievements of the LIFT project, i.e. to "identify the sources of performance and sustainability differences between farms of different types, size and output complexity as observed in the landscape of the European Union (EU)". It is based on collaborative research on Task 3.5 'Employment effects of ecological farming at the farm level' of LIFT between UNIKENT (England) (Task Leader), INRAE (France), DEMETER (Greece), MTA KRTK (Hungary) and IRWiR PAN (Poland).

The analyses reported consider the differences between farms on a scale from the most conventional farming systems to the most ecological as measured by the intensities of use of external inputs and labour, the receipt of agri-environmental payments (AEP), capital and involvement in organic production. This approach was used since, at the time of working on the deliverable the LIFT typology protocol on how to classify farms according to the different degrees of adoption of ecological approaches to farming has not been completed. The approach nevertheless makes use of the LIFT conceptual typology in Deliverable 1.1 (Rega *et al*., 2018). In the analysis, intensity of labour use is studied as a function of farming inputs (fuel, fertiliser, crop protection chemicals), capital and AEP. Dependent and independent variables have been standardised by dividing them by the output value and the resulting ratios named intensities of use. The standardisation by dividing by the overall output value was done to remove the effect of different farm sizes and to focus the discussion on the way output is produced, rather than how land is used. In order to reduce the impact of quality differences in the inputs, we make use of monetary value of input used to take account of quality differences that would be reflected in price differentials. Five EU Member States (MSs) are analysed in this deliverable, i.e. those involved in Task 3.5 – Greece, France, Hungary, Poland and England or the United Kingdom (all data collected refer to when the UK was a MS).

Two types of data are employed in the deliverable - secondary, i.e. data from the Farm Accountancy Data Network (FADN) for the period 2004-2015 and primary, i.e. data from the LIFT cross-sectional large-scale farmer survey carried out in 2019-2020 and referring to the year 2018. The literature review is a summary of LIFT Milestone 16 (Davidova *et al*., 2019), which included a structured literature review as part of Task 3.5, expanded by additional sources. This deliverable also uses a qualitative method, the Delphi exercise, to give further insights and supplement the literature.

This approach is also related to Task 3.2 'Assessment of farm technical-economic performance'. Labour use is analysed relative to productivity and profitability within the intensities. A lower intensity of input use relative to output indicates an ecologically less intensive farm, but it is also a farm that is potentially more productive and profitable.

The analysis of the impact on the labour share of output shows a consistent picture across analysed EU MSs. Low intensities of external inputs and capital, which proxies farms employing ecological approaches, increases the intensity of labour use when external input and capital input intensities decrease. As farms become less intensive in their use of purchased inputs, the intensity of total labour (or labour's share of output) falls and this is primarily driven by a lower intensity in the use of family labour. However, after a certain threshold of input and capital intensities there is a switch to a substitution effect. Therefore, conventional farming, not defined here as non-organic or any other defined system of farming but characterised here by intensive use of externally purchased inputs and highly capitalised farms, drops in labour intensity as the intensity of purchased inputs increase.

Returns to skills in ecological farming have been estimated based on the data from the LIFT large-scale farmer survey and this analysis has only covered LIFT case study areas. The explorative picture based on the survey data has been expanded by a common econometric analysis of the case study areas in

France and England. The comparative study raised questions about the educational systems in the two countries which could influence the innovative capacity to employ new farming technologies.

The data sources did not allow for a systematic analysis of gender effects through adoption of ecological farming approaches, but some insights were taken from the literature review and Delphi exercise. Gender becomes more and more important from the point of view of employment, division of labour within the farm households and pay. However, the studies are on developing countries where customary traditions and norms are much stronger. This literature review shows that the impacts of introducing ecological practices in agriculture in developing countries does not have a clear-cut gendered effect on labour. The effect depends on on-farm labour division and on intra-household time allocation.

Several conclusions and policy implications have been formulated on the basis of the deliverable:

- There is no theory that can guide researchers to *a priori* expectations about the effect of different farming practices on labour demand in quantitative terms and qualitative ones (skills).
- Farms which use ecological farming practices may decrease their intensity of labour use as their intensity of use of purchased inputs and capital is lower. Therefore, policies which support the adoption of ecological farming approaches may have as a by-product increased (maintained) farm, and consequently, rural employment.
- AEP and the increased complexity of output, proxied by the number of enterprises (activities) on a farm, which is expected to be present in the farms using ecological farming practices, also result in higher labour intensity.
- Ecological approaches to farming will mainly increase the use of hired labour strengthening the existing trend of substitution of hired to family labour.
- Cost minimising farmers might be reluctant to adopt ecological farming practices trying to minimise labour costs. Policy incentives might be necessary to stimulate the adoption of ecological farming practices, e.g. agroecology, since the latter has a high potential to provide important environmental and social non-product benefits.
- Government policies, concerning labour market, should be re-orientated towards a decrease of transaction costs for a farmer hiring/firing farm labour to allow more flexible adjustments of hired labour in view of wider adoption of ecological farming practices.
- Agricultural education should provide a broad skill set necessary for the implementation of ecological approaches to farming, thus encouraging a successful adoption of ecological technologies and a positive economic return from their adoption.
- Further research should focus on a comparative study of best practice in the EU: i) in the area of employment law concerning agriculture to provide policy insights on how to build more flexibility in the market for hired farm labour and ii) in the area of agricultural education and practical training.

2 Introduction

The LIFT project argues that there might be different socio-economic outcomes of farming systems within the continuum from most conventional to most ecological farming[1]. Farms implementing ecological approaches are expected to deliver a more balanced bundle of multiple outputs (food, fibre and fuel, public goods, ecosystem services) than more conventional farming practices. Farms implementing ecological approaches are assumed to require, in comparison to more conventional farming, less purchased inputs, implement different technologies and contractual arrangements, and use different quantity of labour, as well as labour with different / higher skills.

This deliverable is based on the collaborative work on Task 3.5 'Employment effects of ecological farming at the farm level' between five LIFT partners - UNIKENT (England) (Task Leader), DEMETER (Greece), INRAE (France), MTA KRTK (Hungary) and IRWiR PAN (Poland). Its main objective is to investigate the employment effects of different farming systems. Thus, the research is based on the assumption that farm heterogeneity, implied by farms' structural and technological differences, affects farm employment.

The analyses are carried out at farm level, employing both secondary and primary data. The effects on the quantity of labour used are based on the analysis of the existing datasets from the FADN. Since the FADN does not include data on the qualitative attributes of labour employed, we need to adopt a novel approach to consider labour quality. The focus on skills uses the unique evidence provided by the primary data from the LIFT large-scale farmer survey (see LIFT Deliverable 2.2, Tzouramani *et al.*, 2019). The analysis investigates whether returns to skills differ according to the farming system.

All efforts have been made to carry out the research considering the differences between farms on a scale from the most conventional farming systems to the most ecological since by the time of working on the deliverable the common LIFT typology protocol on how to classify farms according to the different degrees of adoption of ecological approaches based either on FADN or LIFT large-scale farmer survey data has not been completed (LIFT Deliverable 1.4, Rega *et al.,* 2021). The approach used in this deliverable nevertheless makes use of the LIFT conceptual typology in Deliverable 1.1 (Rega *et al.*, 2018). Five EU MSs are analysed, i.e. those involved in Task 3.5 – France, Greece, Hungary, Poland and England or the United Kingdom (all data collected refer to when the UK was a MS).

The deliverable is structured in six sections. The next and the more general one includes literature review, overview of commonalities and differences in agriculture and labour markets in the five EU MSs covered, and insights from the implementation of Delphi method, included in LIFT Deliverable 4.2 (Bailey *et al.,* 2021), which help formulate some prior expectations on the effect of ecological farming approaches on labour use and returns to skills. Section four includes the study of the effect of ecological approaches on on-farm labour use and the fifth section analyses the effect of ecological approaches on skill requirements and returns to skills. Conclusions and policy implications are presented in section six.

[1] Ecological practices are understood in LIFT as low-input practices and/or practices that are environmentally friendly. The originality of LIFT in this view is not to focus on a specific type of ecological approaches, but to cover the whole continuum of farming approaches, from the most conventional to the most ecological, including the widest range of ecological approaches. This comprises the existing nomenclatures such as organic farming, low-input farming, agroecological farming, etc. It also encompasses approaches that are not yet part of a nomenclature, but that can be identified with various criteria such as management practices, on-farm diversification etc. Thus, conventional practices mean non-ecological practices.

3 General overview of literature and countries' agriculture and labour markets

3.1 Brief literature review

This review is based, but not exclusively, on LIFT Task 3.5 Milestone 16 (Davidova *et al.,* 2019), which included a systematic review on ecological farming approaches and their effects on labour.

3.1.1 Methodology

The basic search string was applied to the Scopus (https://www.scopus.com/) and Web of Science Core Collection (http://wok.mimas.ac.uk/) databases. The gender discussion also used EconLit (https://www.ebsco.com/products/research-databases/econlit). Starting with words related to labour, a search string started to emerge. The final search string used is shown in Table 1:

Table 1: Search string used

Field	Search String	Logic Operator
Title, abstract or keywords	Labo* OR "job creation" AND "job destruction" OR employment AND NOT laboratory	AND
	"sustainable agriculture" OR ecolog* OR agro* OR conventional OR integrated OR organic OR conservation OR "low input" OR extensive OR intercrop* OR "low intensity" OR silvo*	
	Agri* OR farm*	
	Skill* OR gender OR sex OR season* OR part OR full OR total OR hired OR family OR migra* OR socio-economic	
	Austria OR Australia OR Belgium OR Bulgaria OR Canada OR Croatia OR Czech Republic OR Denmark OR England OR EU OR "European Union" OR Finland OR France OR Germany OR Greece OR Hungary OR Ireland OR Italy OR Lithuania OR Netherlands OR "New Zealand" OR Poland OR Romania OR Scotland OR Slovakia OR Spain OR Sweden OR "United Kingdom" OR "United States"	

The next part of the search string used keywords as identified in Rega *et al*. (2018) (LIFT Deliverable 1.1): agroecology, organic, integrated, low-input/extensive, conservation agriculture and conventional. Also included was the general term "sustainable agriculture" as well as other related keywords.

Another consideration for the literature was its geographical coverage and relation to the stage of development of the country and its agriculture. Therefore, the search string also focused the search on countries that are within, or have a similar agricultural system to that of, the EU. Limits were applied to the search mainly in the form of subject area: documents appearing in energy, mathematics, medicine, computer science were excluded. Another limit was placed on time, to exclude everything written before 1993 because in 1992 a reform to the Common Agricultural Policy (CAP) introduced agri-environmental measures (the MacSharry reform). This reform provided a motivation for research into how agri-environmental measures affect agriculture in the EU. However, this time limit did not make a great deal of difference in the search results.

Using the above search string, 429 documents were found in Scopus (201 in Web of Science). In addition to these results, we have augmented the findings with some other relevant papers known to the authors.

3.1.2 Labour demand on organic versus conventional farms

Using different methodologies, several authors claim that organic farming (one of the ecological types within the spectrum from most conventional to most ecological farming practices) uses more labour than conventional farms (e.g. Offermann and Nieburg, 2000; Morison *et al*., 2005; Finley *et al*., 2018). Jansen (2000) argues that it is necessary to control for farm (production) type, timing and the size of the farm. Studies reviewed by Jansen show that there are large variations in labour use across different farm types. Concerning farm size, labour use has been much higher on small organic farms than on large ones. A larger farm allows for an easier substitution of mechanisation for labour on both organic and conventional farms. Morison *et al*. (2005) used a large survey of 1,144 organic farms in the United Kingdom and the Republic of Ireland to determine whether non-organic or organic farms provide more employment. They found that 135 per cent more full-time equivalent jobs (FTEs) were provided by organic in comparison to non-organic farms. These authors attribute the increased labour requirement to more complex rotation systems, mixed farming, cultivation of crops such as vegetables and fruit that are more labour-intensive, and less mechanisation. Lobley *et al*. (2009) support these findings providing some more detail, i.e. that in conventional farms 55 per cent of labour is full-time, 22 per cent part-time and 23 per cent casual/seasonal workers, while in organic farms these percentages are 44, 21 and 35 respectively.

However, using results from studies on organic farming to lead to *a priori* expectations about the effects of ecological approaches on labour use might be ambiguous since there is a debate in literature on the "conventionalisation" of organic farming (e.g. see Konstantinidis, 2016). Konstantinidis finds that organic farming does not necessarily lead to a higher labour intensity. The supporters of the "conventionalisation" of organic farms in Europe claim that it is true that such farms do not use synthetic fertilisers, pesticides and herbicides, as used in conventional agriculture, but at the same time organic farms may be growing in size and specialisation, and mechanisation may be replacing the greater quantity of labour used on the farms.

3.1.3 Broader studies on agricultural labour demand

Beyond the bulk of research on organic farms, Dries *et al.* (2012) use FADN data to study agricultural adjustments - job creation and job destruction - in the EU. The authors find that, overall, in the period 1990-2005 job destruction rates were higher than job creation, and that the rates in relation to family and hired labour were similar to the aggregate for the sector. Employing a cell-based regression model, their results show that technological differences between farms (in view of input and capital intensities) do not explain job creation rates and play a limited role in the contribution to the explanation of job destruction rates. An important explanatory factor are idiosyncratic shocks (e.g. weather, farm household crises). This suggests, similarly to the "conventionalisation" of organic farming, that results of previous research are ambiguous concerning the significance of the effect of farming practices on labour use, as there might be other factors contributing stronger to the farm labour dynamic.

Some papers deal with the effect of EU CAP on the labour market (e.g. Mills, 2012; Petrick and Zier, 2012; Dupraz and Latruffe, 2015). These authors reported results related to the employment effects of policy schemes focused on agri-environment which are relevant to this deliverable. Mills (2012) looked broader at the social benefits of agri-environment schemes (AES) beyond the targeted environmental benefits. The analysis was based on data collected through 360 interviews with environment schemes agreement holders in England. Altogether, 27 per cent of respondents reported increased workload due to their participation in AES. Logically, holders of High Level Stewardship agreement (a land management scheme in England which involves more complex management commitments than the Entry Level Stewardship) had higher workload.

Dupraz and Latruffe (2015) argue that, in general, crop area payments and Single Farm Payments have reduced farm labour, while AEP, Less Favoured Area payments and investment subsidies have increased it. Pufahl and Weiss (2009) applied a non-parametric difference-in-differences propensity score matching approach to evaluate the effects of participation in AES in Germany and found a positive relationship between farms participating in AES and their on-farm labour. Mettepenningen *et al*. (2009) reported two types of costs requiring more labour input in farms participating in AES in the EU – private transaction costs and field costs.

Petrick and Zier (2012) argue that AEP which generate positive environmental externalities may increase the labour use if the environmental outputs are produced by using a more labour-intensive technology. However, their results on East Germany using regionalised data show that agri-environmental measures had no employment effect in any of the four fixed effect specifications they ran. Therefore, although logically it is expected that AEP may increase labour use due to the contractual requirements of the AES, this has not always been supported by research.

EU funded collaborative research projects also bring useful insights. In the current LIFT project, Rega *et al*. (2018) (Deliverable 1.1), based on a structured literature review, classified the ecological approaches to farming in six hierarchical clusters starting from conventional agriculture and moving towards the most ecological. The first cluster, conventional agriculture, is defined as based on chemical inputs and intensive farming. One of the characteristics of the next cluster, conservation agriculture (CA), is minimum, reduced or no-tillage. The third cluster includes low input systems. The next ones are integrated farming systems, which also include mixed crop-livestock farming. The last ones are organic farming and agroecology, including biodiversity farming systems. This classification has been useful to devise variables for the quantitative analysis in the current deliverable.

However, it is difficult to generalise for the whole EU. For example, the Sustainable Organic and Low Input Dairying (SOLID[2]) project argues that a common definition of “low input” and “high input” farming within the EU might be misleading due to the heterogeneity of production practices. Thus, what could be qualified as “low input” in countries with input intensive dairying, might be “high input” in other EU MSs. Therefore, a country-specific definition is necessary. The authors in the SOLID project used the full distribution within a MS of an indicator measuring the external inputs per cow – and classified the lowest 25 per cent of the distribution as low input dairy farms, specific to that country, and the highest 25 per cent as the high input ones. Applying such a definition, their results indicated that the low input farms are smaller both in terms of the number of cows and the utilised agricultural area (UAA). From the point of view of labour demand, low input dairy farms have had the lowest employment rate in comparison with high input farms and organic farms, high input farms have the highest employment rate, while the organic farms are between the two extremes. However, the labour requirements differ by MS, and in some countries there is no discernible difference between farms, thus, it is difficult to generalise for the EU as a whole. The difficulty to draw generalised conclusions is also reflected in relation to adoption of better soil management practices (Pronk *et al*., 2015). For example, a switch from conventional to low tillage saves on labour costs, as well as on fuel expenditure; the magnitude of the savings per hectare differs between the EU MS. However, another management practice, cultivating cover/catch crops and green manure, requires more labour. Whether better soil management practices require more or less labour, or help avoiding labour peaks depends on several factors, including the soil type and the practice under consideration.

Concerning external inputs of interest to the empirical analysis in this deliverable, a report by the UK Department for Environment, Food and Rural Affairs (DEFRA) looked at practices which can reduce fertiliser input but maintain yields and indicated that 24 per cent of farms used precision farming tech-

[2] http://farmadvice.solidairy.eu/how-to-make-a-living/

niques to guide fertiliser application, 27 per cent used soil nutrient software packages which help determine the correct quantity of fertiliser application and 17 per cent of farmers used green manures as part of their arable rotation (DEFRA, 2020). Based on the England Farm Business Survey which provides data for the EU FADN, Townsend *et al*. (2015) studied the tillage related to the use of fuel and reported that 46 per cent of English arable farms used reduced tillage methods. Using reduced tillage allows farmers to save on labour, machinery and fuel costs (Jarvis and Woolford, 2017). Crop protection products are subject to strict regulations and farmers are threatened with restrictions or bans. Losing some of these products would require farmers to adjust their method of crop protection to a greater reliance on mechanical and hand weeding – an increase in labour requirement (The Andersons Centre, 2014). This is especially the case in the horticultural sector and may also result in a higher labour need for grading fruit or vegetables depending on weight, shape, size or colour.

3.1.4 Skills

In relation to skills of people engaged in ecological farming, Mills (2012) argues that the participation in AES contributes to the improvement of human capital, increasing farmers' skills to farm more sustainably. 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 cultivating diversified farms required more complex methods due to different crop requirements and plot agronomical constraints. Since the production process is more complex, the farmers also needed 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' decision to participate in AES is due to a combination of business interests to capture AEP revenues and because the schemes often required only small adaptations of existing farming practices or no change at all (Harrison *et al*. 1998; Wilson and Hart, 2001; 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 over 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 constrained the development of farmers' abilities to develop and implement innovative ideas.

3.1.5 Special focus on gender

There is no study focusing on gender in developed countries. The impacts of introducing ecological farming approaches in developing countries does not have clear-cut gendered effects on labour. The effects depend on on-farm labour division and on intra-household time allocation. Female family labour may be relieved by the introduction of specific technologies, but in some other cases, the demand for their labour is higher, putting more pressure on them. As argued by Rahman (2000), in poor households women face numerous demands of labour for economic and domestic activities, and work longer hours than men to accommodate all demands. In some cases, the introduction of specific technologies has a negative effect on hired female labour, a society's group who is the most vulnerable in some countries. This brings us to the unresolved and more philosophical question of what is positive. As highlighted by Gathorne-Hardy *et al*. (2016) "should displacement of agricultural labour be seen positively for reducing drudgery, or negatively for reducing employment?", or, in other terms, "what is the counterfactual to an agricultural labourer's job – a better job, or no job?". The author suggests that this depends on the point of view: from the society's point of view, fewer jobs with difficult physical conditions represent progress; but from the point of view of an individual who cannot escape rural work for various reasons, "any job is better than none". Such individuals are typically landless women in poor rural areas, especially when they are in a lower class of the society, such as a low caste.

The gendered employment effects of a change in technology/farming practice depends on the tasks where women and men, respectively, are more or less involved. This task division itself depends on whether a specific task suits the physical abilities of a gender and whether there are social or cultural constraints to labour allocation. As explained by Nyanga *et al*. (2012): "Men and women participate differently in agriculture and development interventions affect them differently. This is because of gender differences and the socially acquired notions of masculinity and femininity by which women and men are identified".

Gender stereotypes about capabilities play a strong role in some countries and may affect men and women's labour opportunities and welfare differently. This may also impact overall farm survival, since, as noted by Holden *et al*. (2001) "cultural restrictions reduce the substitutability of male and female labour and the scarcity of one type of labour may cause inefficiency unless the labour market works well", which is not always the case, particularly in developing countries. This calls for the need to take into account the regional dimension in analyses of labour, as underlined by Rahman (2000).

3.1.6 Conclusions of literature review

In summary, the literature review suggests that there is no theory that can guide researchers to *a priori* expectations about the effect of different farming practices on labour use and skills. The quantitative and qualitative labour effects resulting from the implementation of more or fewer ecological farming approaches is, therefore, an empirical question.

The gender section of the structured literature review has underlined the lack of studies in developed countries. Although cultural norms may be less strong than in developing countries, there are expectations concerning female and male in the society as a whole, and probably in agriculture. How this may influence labour demand, changes in ecological in comparison to conventional farming remains to be investigated.

3.2 Insights from Delphi exercise

In order to have some preliminary insights of what could be expected, we used some findings from Delphi analysis, carried out in LIFT Deliverable 4.2 (Bailey *et al.,* 2021).

3.2.1 Introduction

One widely used approach to study *what can happen* is the Delphi method. The Delphi method attempts, first, to collect the views and opinions of a number of informed people (stakeholders) and, second, to harmonise these views across a panel of experts (Börjeson *et al*., 2006). Gallego and Bueno (2014) define Delphi as a type of questionnaire, which, through feedback, organises and shares opinions. 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.

Based on these principles, a Delphi exercise was designed to investigate the views of participant stakeholders (researchers, land agents, farmers, civil servants, non-government organisation representatives, etc.) on development of ecological farming and its socioeconomic consequences at a 10 year forward perspective in their respective case study area. A preliminary stage was necessary to provide information to the participants on the current characteristics of ecological farming approaches in the case study areas. LIFT researchers used existing local literature, expert knowledge, or data from the LIFT large-scale farmer survey (see Deliverable 2.2, Tzouramani *et al.,* 2019) to characterise farms using ecological versus conventional farming approaches depending on the practices they employ. Average data of these two groups (ecological and conventional farms), including farm size, application of chemicals per hectare, number of different crops grown on a farm etc., was used to characterise "typical" ecological and conventional farms for each case study area covered by the Delphi analysis. In the first round of Delphi, expert knowledge combined with these average statistics were presented to the respondents who were asked to give their views on how the differences in the farming practices and characteristics of ecological and conventional farms might develop in their area in a 10 year forward perspective. In rounds 2 and 3, respondents were asked whether ecological farms will develop in clusters or will be randomly spread across the territory; and to approximate the rate of adoption (whether a "low" 10 per cent or "high" 50 per cent of the agricultural area will be used by farms which will adopt ecological practices). These scenarios concern the possible future development of ecological farming in the respective area and present a foundation on which each respondent is asked for their opinions on the socio-economic effects of a transition to the anticipated scenario in 10 years' time. The researchers summarised these opinions and, as suggested by theory to iterate through rounds and feedback, presented them again in round 3, asking the respondents if there were any revisions to be made based on the feedback. Finally, the Delphi exercise looked for signs of convergence and consensus.

3.2.2 Round 1 findings

Concerning the development of farming practices, respondents tended towards the proliferation of ecological farming but in parallel with the continuous existence of conventional farming. The prevailing opinion was that in 10 years more farmers would use regenerative farming principles: lower use of synthetic fertilisers and pesticides (replaced to some degree by organic fertilisers and overall reduced use through precision farming and biological controls); higher use of organic manure and compost; an increased use of minimum or zero tillage methods; increased crop-livestock integration; more/larger wildlife strips, margins, buffer strips, beetle banks, woodland and hedgerows; wider use of cover crops. Respondents underlined that one of the typical characteristics of conventional farms that would continue would be the implementation of externally purchased inputs, while more ecological farms would minimise the use of these inputs.

3.2.3 Rounds 2 and 3 findings

Overall, stakeholders thought that there would be a slight decrease in total farm employment. As technology further develops and precision farming (including, but not limited to, smart farming with artificial intelligence (AI), robots etc.) is incorporated into management and monitoring activities, all inputs will be used more efficiently and a farm would be able to adopt ecological farming practices whilst also reducing labour use. However, the processes would be complex including substitutability and complementarity. Several participants foresaw that ecological agriculture will be linked to lower farm incomes and therefore, farmers would try to decrease labour costs which would drive towards higher mechanisation. As a result, lower incomes may lead to a decrease of farm employment. However, this decrease might be offset, at least partially, by a possible increase of labour use due to the integration of crop and livestock on some ecological farms and the development of agroforestry.

In relation to labour skills, it was argued that ecological agriculture will 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. In more concrete terms, 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.

Concerning gender balance, although consensus was not achieved, based on their own experiences some participants argued that women are very good with environmental issues, e.g. conservationists and ecologists are more likely to be women than men in the Wildlife Trusts. Therefore, women may be more attracted to a type of farming incorporating more ecological practices. However, other participants argued that there should not be a gender effect of ecological approaches to agriculture.

3.2.4 Conclusions from the Delphi method

Results from the Delphi method indicated two important points informing the quantitative analysis in this deliverable.

First, ecological farming will create a complex picture of input and labour complementarity and substitution where farmers try to maximise their joint production of marketable agricultural products and environmental output, but minimise their costs that include labour. Indeed, reducing their inputs of fuel, herbicides and pesticides, and fertilisers might result in an increase in farm environmental output which is one of the main objectives of the ecological approaches to agriculture, and depending on the labour intensity of this output, employment might increase or decrease.

Second, to the extent that skills are concerned, a prevailing opinion of Delphi respondents has been 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.

3.3 Overview of agricultural and rural labour market in analysed EU Member States

This section summarises the commonalities and differences in farm and rural labour markets in the five EU MSs participating in Task 3.5. Though the sources of data in this section vary: most of the data comes from national statistics (either from the National Statistical Offices or Ministries of Agriculture), some data originates from Eurostat, FADN is used in the overview for Hungary, and the UNIKENT team leading this deliverable consulted the World Bank Development Indicators (World Bank, 2020.) and OECD Skill Indicators (OECD, 2016 and 2017). This implies somehow different definitions, different dates for the most recent development, and thus, not full cross-country comparability could be ensured.

3.3.1 Country comparison of relative agricultural importance

One of the largest differences between the MSs is in the relative importance of agriculture. According to the World Bank Development Indicators (World Bank, 2020) in 2019 the share of the value added of Agriculture, Forestry and Fishing in the GDP varied from the highest of 3.7 per cent in Greece to the lowest of 0.6 per cent in the UK. However, for the purposes of this study on labour, of central importance is the difference in the share of employment in agriculture in the total employment. According to the World Bank Development Indicators (modelled ILO estimate) in Greece it was at 11.8 per cent in 2020; in France 2.4 per cent, Hungary 4.6 per cent, Poland 8.9 per cent and the UK 1 per cent with an average for the EU of 4.2 per cent (Figure 1).

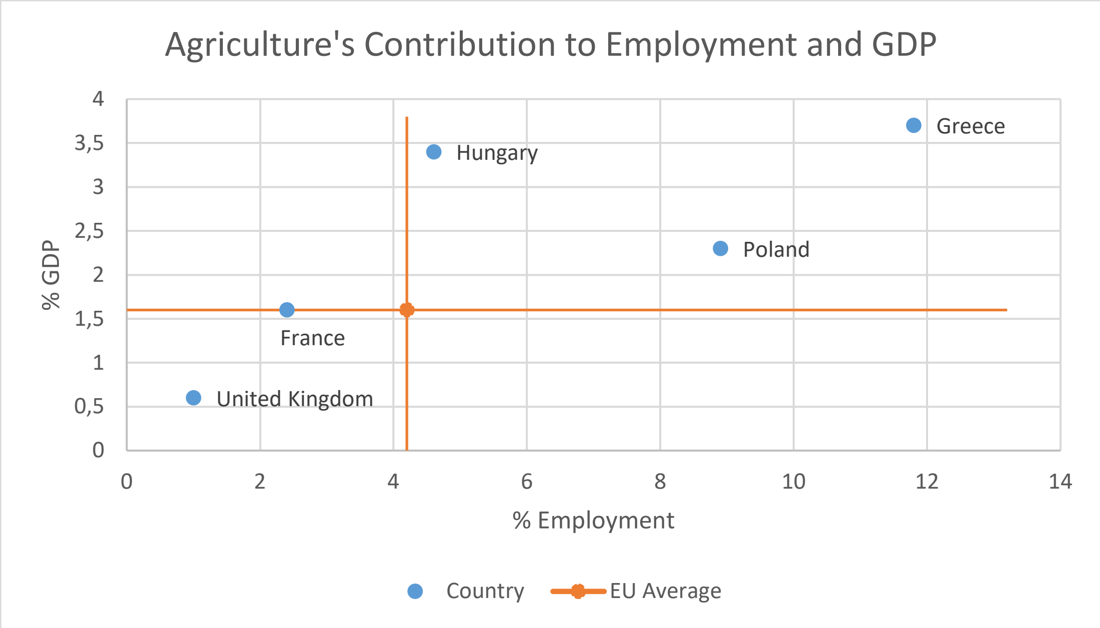

Figure 1: Contribution to employment and GDP from agriculture from selected EU Member States

Therefore, amongst the countries analysed, there are two more agrarian – Greece and Poland, one at the EU average concerning employment – Hungary, and two with very low relative importance of agriculture for employment - France and at the extreme the UK. Figure 1 exemplified that in Greece and Poland the share of agriculture in employment is by far higher that the share in GDP, suggesting a low labour productivity. Concerning labour, the first common characteristics amongst the five countries is that **farm labour has decreased over time**, although with different dynamic in different countries.

3.3.2 French agriculture

In 2016 total farm labour in *France* was 957,383 Annual Work Units (AWU), consisting of 58 per cent farm (family) heads, 7 per cent other family labour, 20 per cent permanent hired workers and 15 per cent non-permanent hired workers (including seasonal labour and labour from contracting). Total farm labour decreased by 27 per cent between 2000 and 2016. The decrease affected all the categories with the exception of the category of non-permanent hired workers, which slightly increased, most probably due to a wider use of contracting on labour. Other family workers (other than farm heads) were most affected by this decline and their AWU decreased by 73 per cent; farm heads decreased by 24 per cent and permanent hired workers by 7 per cent. However, the decline in labour use has not affected negatively the gender balance in French agriculture. During the same period, 2000-2016, the share of female who acted as farm heads increased slightly from 24 to 27 per cent, as well as their share in permanent hired workers from 24 to 28 per cent.

3.3.3 Greek agriculture

In *Greece*, in 2018 total employment was 579,581 people out of which 90,526 were employees[3] and the remaining majority – self-employed (data is for “Agriculture, Forestry and Fishing” sector). During the period 2005-2018 the loss of labour (employees and self-employed) was 12.9 per cent. Three observations are important in the case of Greece – first, the decline stemmed from the decrease in self-

[3] According to the definition of the Hellenic Statistical Authority employees are persons who work for a public or private employer and who receive compensation in the form of wages, salaries, fees, gratuities, payment by results or payment in kind.

employed persons while the number of employees has increased; second, the largest decline occurred during the peak of the Greek economic crisis 2009-2016; and third, the decline has not resulted in higher labour productivity since in relative terms the Gross Value Added dropped more than labour. More precise data on agriculture is only reported for Crete, where labour dynamic is differentiated in four categories: farm holders and their household members employed on the holdings; permanent hired workers; seasonal hired workers; and employment of mutual help between farmers.[4] In the period 2005-2016 (the most recent years for which detailed data is available), the largest decrease was recorded by seasonal hired workers (29.5 per cent), and farm holders and their family members employed on the holding (14.3 per cent). However, both remaining categories increased by approximately 62 per cent each. Therefore, there has been a substitution of permanent hired workers for farm holders and family labour.

3.3.4 Hungarian agriculture

Hungary has not escaped from this tendency but the labour dynamic has been affected by specific additional phenomena, i.e. the consequences of market reforms and farm restructuring which started in early 1990s and accession to the EU in 2004. After the fall of the centrally planned system and the restructuring of agriculture, a dual farm structure emerged with large commercial farms and a great number of small family or subsistence farms. In 2016, the number of commercial farms was slightly below 9,000 (average holding size was 256 ha) and the number of individual holdings was 415,000 (average holding size 7.6 ha), 58 per cent of the latter were subsistence farms with less than 1 ha.

Whilst there has been a monotonously decreasing tendency of labour use in Hungarian agriculture (total labour decreased by 42 per cent between 2000 and 2018, i.e. in AWU from 676 thousand to 391.6 thousand), the discrepancy between the dynamic of the unpaid and paid labour has been striking. During the same period, family labour decreased by half, i.e. agricultural employment of family members lost 265.3 thousand AWU. By comparison, paid labour decreased by slightly more than 19 thousand AWU or by 13.4 per cent. As expected, the fastest drop in paid labour took place during the 2008 – 2010 financial crisis but after that the number of employed started increasing again. The substantial change in the balance between family labour and hired workers reflected the decrease in subsistence farming and the strengthening of commercial farms.

Despite demand of seasonal labour by the fruit and horticulture sector, particularly in commercial farms, and consequently constantly increase in wage, and a “simplified employment” (SE) scheme, that minimises administrative burden for the employer, the seasonal labour decreased as well, although with a rate not much higher than the one affecting hired workers - 15.4 per cent. There have been multiple reasons behind this decline, such as the decreasing and simultaneously aging population, rural out-migration to urban areas and abroad, but also the lack of out of season rural employment opportunities which made seasonal employment an unattractive alternative.

3.3.5 Polish agriculture

In *Poland*, similarly to Hungary, agricultural sector has been affected by the reforms post-1990 and accession to the EU. The farm structure and the relevant statistics in Poland are split into individual farms and others, the latter holdings registered as legal persons and other organisations fully reliant on hired labour. However, the overwhelming part of employment has been on individual farms – in 2016 measured in AWU it accounted for 97.5 per cent. Similarly to the other countries, farm labour has decreased but still, as stated previously, it stayed rather high in relation to the total national employment. The concept used in Poland for the observed decline in agriculture as a source of livelihood

[4] Employment of mutual help between farmers is a common practice in Greece. Farmers help others if they have labour surplus whilst the others experience labour shortages. The farmers do not receive wages for the work they provide, but they receive help in return. One could consider this as a form of barter.

for household is “disagrarianisation”. This process has accelerated, and fewer and fewer people work in agriculture. In the period 2007-2016, measured in AWU, employment in agriculture dropped by 67 per cent mainly due to the decrease in labour on individual farms, whilst labour in the other holdings increased by nearly 12 per cent. Within the individual farm sector, similarly to Hungary, the decline was driven by the family labour (70 per cent) when hired labour, contract employees and shared labour between neighbours has increased.

3.3.6 UK agriculture

In the *UK,* the importance of agricultural employment in the economy is insignificant. The latest figures from the Office of National Statistics (ONS) for 2016 showed 1.07 per cent of the population working in agriculture, forestry and fishing, equivalent to roughly 350,582 people (ONS, 2019). However, DEFRA in their 2015 June survey indicated 477,000 people (DEFRA, 2019a). There are several reasons for this discrepancy. DEFRA carries out the survey in June when most of the seasonal and migrant workers are in place; the ONS does not count people in temporary or communal accommodation on-farm. Of the number reported by DEFRA, 62 per cent were farmers, business partners, directors and spouses, and the remaining 38 per cent regular employees, salaried managers and casual workers. The latest figures published by Eurostat indicate that agricultural employment, measured in AWU, has decreased by 2.7 per cent since 2005 (Eurostat, 2020) with the biggest drop around the time of the financial crisis, in particular in 2010, with a slight increase since then. Most of the fluctuations were due to family labour.

Concerning the gender balance, the agricultural industry in the UK is male dominated. Farm holders, managers and non-family workers are predominantly male (around 80 per cent); only family labour is more balanced - 45 per cent female.

3.3.7 Agricultural income and wages

The other common tendency in the analysed countries has been that **incomes and wages have increased** but again with different rates in different countries. One notable exception is *Greece* where the economic crisis and austerity policy in the period 2005-2017 triggered a decrease in employees' compensation[5] in both in the “Agriculture, Forestry and Fishing” sector by 37.5 per cent and in “Crop and Animal Production, Hunting and Related Service Activities” by 41.1 per cent. The largest annual drop was recorded in 2009.

In *France* the gross hourly wages for permanent and non-permanent hired labour have increased. For permanent hired labour the wage increased from €8.83 in 2000 to €13.36 in 2016. The figures for non-permanent hired labour (excluding contracting labour) were €7.56 and €11.14 respectively.

In *Hungary*, agricultural wages have been lower than in industry, services or even the public sector where wages are by far lower than in the private businesses. Net average earnings in the sector of Agriculture, Forestry and Fisheries have been the lowest in comparison to other sectors, e.g. industry and construction, but in the period 2008-2018 they still displayed an increasing trend. However, it should be considered that the national currency depreciated strongly during this period[6]. By the beginning of 2020, the average gross earnings in agricultural sector equalled to 78.5 per cent of the average for the national economy.

In *Poland*, the accession to the EU brought about a major change because it in a sense “appreciated the status” of agriculture, facilitated migration (both domestic and international) and fostered the creation of new jobs directly in rural areas. This produced greater income dynamics of rural than urban residents (including those living in largest cities), although in terms of income levels in absolute terms

[5] Compensation of employees consists of wages and salaries in cash or in kind and employer's actual and imputed social contributions.

[6] Whilst in mid-2008 the €/HUF exchange rate was around 230 HUF/€, by 2018 it was 310-320 HUF/€.

rural residents still earn less than residents of cities (Foundation for the Development of Polish Agriculture, 2019). In 2004-2016, nominal per capita incomes of rural residents rose by 118 per cent, and those of urban residents – by 94 per cent. The higher income dynamics of rural in comparison to urban residents has been driven by the improved income situation of farmers due to the CAP support. During the period 2004-2016, the incomes of farmers' households rose by 113 per cent, whilst the average increase per household was 101 per cent. However, despite this positive dynamic driven by people engaged in agriculture, in 2016 the disposable income per capita in rural households was approximately 26 per cent lower than in the cities due both lower incomes in absolute terms and larger households in the countryside.

In the *UK*, average weekly earnings have steadily increased year by year (apart from small decreases between 2006-2007 and 2010-2011). In 2019 average weekly earnings were 88.1 per cent higher than in 2000 (ONS, 2020a). However, wages in "Agriculture, Forestry and Fishing" continued to be lower on average in comparison to the national economy, i.e. £413 average weekly earnings versus £538 respectively.

3.3.8 Education and skills in agriculture

Although education and skills in agriculture have improved, they still lag behind the general education level and employers requirements. OECD in their Skill Needs Indicator (OECD, 2017) provide comparable information for "Agriculture, Forestry and Fishing". The scale of the indicator ranges between -1 and +1 across multiple skills dimensions. A negative value of the indicator implies that a skill surplus exists, whereas a positive value indicates a skill shortage. A larger value of the indicator points out to a larger disbalance between skill needs and skills available per country and industry. A skill shortage occurs when skills sought by employers are not available in the pool of potential recruits; whereas a skill surplus occurs when the supply of certain skills is higher than the demand for them. OECD published the indicator for 2015 for four of the countries analysed in this deliverable (no data for the UK). Greece, France and Poland have shortage of skills on all dimensions studied by OECD (content skills, e.g. reading, writing, active listening; process skills, e.g. active learning; complex problem-solving skills and social skills). Differently, Hungary has a surplus of skills.

3.3.9 Agriculture in the rural economy

In all studied countries **agriculture is a minority employer in rural areas**. In *France*, the data below is in relation to the so-called living areas which are constituted of several municipalities, and similarly to municipalities classified in the categories of urban, peri-urban and rural. Tertiary activities (services) are the predominant employer in rural areas accounting in 2007 for more than 50 per cent of total rural employment. Their share has constantly increased over the period 2007-2016 while employment in all other sectors declined. Although not the main employer, agriculture is still relatively important for jobs in rural France - it ranks fourth with 14.6 per cent of rural employment, very close to the share of industrial jobs (15.3 per cent). Concerning labour dynamic, agriculture and industry were the worst performing sectors with a sharp constant decrease over the whole period – 2007-2016.

In *Hungary*, the share of agricultural employment in rural areas was almost twice the country average although the situation may have changed since the data available is for 2011 (9.0 per cent and 5.5 per cent respectively). The share of manufacturing jobs was 34.5 per cent in 2011, while the services sector was the most important employer with 56.5 per cent. However, the importance of employment in agriculture might have been higher than indicated by official figures due to part-time jobs, informal economy and traditional agricultural households. The rate of rural unemployment is spatially uneven, with very high rates in the Eastern-North-Eastern and South-Transdanubian areas.

In *Poland*, in comparison to 2006 rural employment in 2016 increased. However, more and more rural residents find employment in non-agricultural sectors and, thus, persons working in entities related to agriculture, forestry, hunting and fishing constituted only 4.7 per cent. The regional structure of the rural employment by sector shows a great diversity. A significant percentage of those employed in agriculture related sectors, over 10 per cent, are in 3 voivodships: Zachodniopomorskie, Lubuskie and Warmińsko-Mazurskie, but overall, in comparison to 2006, the majority of voivodships (with the exception of the Lubuskie) recorded a decrease in the share of people employed in agriculture, forestry, hunting and fishing.

The economic structure of rural areas in the *UK* has become more diversified and less reliant on agriculture, thus, more employment has been created in manufacturing and services than in agriculture. In England, there were around 545,000 businesses registered in English rural areas in 2017/2018 (DEFRA, 2019b). These businesses employed 3.6 million people[7], which is equivalent to around 13 per cent of people employed by businesses registered in England. Of these registered businesses, 15.2 per cent are within the sector of "Agriculture, forestry and fishing" (DEFRA, 2019b). In absolute terms, sectors such as "Manufacturing", "Wholesale, retail and repair of motor vehicles", "Education, health and social work" employ more people than agriculture.

3.3.10 Agricultural policy

There is a **wide variety of measures to regulate agricultural labour markets most of which provide a more favourable treatment of agriculture** in comparison to the remaining economic sectors. Since the EU does not have a harmonised social policy, it is to be expected that the national regulations of agricultural labour markets are quite diverse.

In *Greece* since 2017 a Single Social Security Entity has been in place and all working population (hired, self-employed, farmers) are insured there. However, farmers pay lower social security contributions. Farmers who also work as hired workers elsewhere pay both contributions as hired workers and as farmers. For farmers to register to the Single Social Security Entity, they need to have a minimum annual income of €4,923, i.e. €410 /month. However, there exist exceptions to this rule. The tax system is (more or less) the same for everybody.

In *France,* there is a specific tax system for agriculture. The farm revenue ("bénéfice agricole") is taxed with a specific rate, except for small farms with no bookkeeping or farms with low revenue (less than on average €82,800 gross revenue over the recent three years), where a flat rate is applied ("micro-bénéfice agricole"). The farm sector also has a specific social security system, managed by the Mutualité Sociale Agricole (MSA). The social security contributions are deducted from the farm revenue before the tax rate is applied.

Additionally to CAP Pillar 2, there is a specific policy for rural areas with low population density. In essence, it is a tax exemption programme targeted at firm creation and employment in rural areas. It is similar to the US Enterprise Zones (EZ) and it is called "Zones de revitalisation rurale" or ZRR. The programme is a wage subsidy, in the form of employer payroll tax exemptions, targeting a subset of jobs located in the rural EZs (Behaghel *et al.*, 2013).

In *Hungary*, several schemes regulating the labour market have been introduced. In order to facilitate the employment of seasonal workers, a SE scheme was introduced to make the hiring more flexible with lower transaction costs for the employer. The scheme was designed specifically for agriculture and tourism. A person could be employed through SE for a maximum of 120 days/calendar year. Minimum wage has also been introduced. Since 1st of January 2019 monthly minimum wage, applicable also to agriculture was fixed at HUF 149,000 (lower for public sector workers). This minimum wage has been differentiated according to education level and for those with secondary education, including in agriculture, was HUF 195,000.

[7] The location of registered businesses is defined as rural and urban, thus, the classification applies to where the jobs are located rather than where the employees live.

Poland maintains a special Farmer's Social Insurance System administered by the Agricultural Social Insurance Fund (KRUS) strongly subsidised by the Government. It is entirely separate from ZUS which manages the social insurance fund for other workers. Regulations for KRUS have been criticised in the academic literature since they maintain incentives for fragmented land ownership and hinder business entrepreneurship in agriculture. In order to transfer from the general ZUS national insurance to KRUS, which is more attractive since it is strongly subsidised, one should satisfy several conditions, including owning at least 1 ha of agricultural land of particular quality (land class), de-registering the business activity previously conducted, in practice meaning to leave ZUS. After reporting to KRUS, the future farm entrepreneur must be insured in KRUS for at least 3 years and cannot run a business for a period of 3 years or be employed as a full-time employee; only self-employed farming and employment under a work contract is allowed.

Agricultural workers in *England* must receive at least the National Minimum Wage, but if employed prior to the change in rules on 1st October 2013 and their contract specifies so they may be entitled to the Agricultural Minimum Wage when it is higher than the National Minimum Wage. The National Minimum Wage is differentiated by age only, e.g. in 2020 the hourly wage was £8.21 for those aged 25 and over; £7.70 for those between ages 21 to 24; £6.15 for those between 18 and 20 and £4.35 for those aged 18 and below. The Agricultural Minimum Wage has been adapted better to the experience and the required skills for the hired worker's job. For example, if the average farm worker has a median hourly wage equal to £8.98, an experienced worker gets £10.17, whilst workers in animal care get £8.74, in machine operation – £8.90 and in equipment management – £9.63.

3.3.11 Summary

First, although the directions of change are in general common, the rates of change differ substantially between the countries analysed. Due to the economic crisis and austerity policies, Greece is an outlier in certain aspects of the labour market (e.g. compensation of employees).

Second, a substitution of permanent hired workers for farm holders and family labour is observed.

Third, the dramatic change in the balance between family labour and hired workers in the two EU NMS - Hungary and Poland - reflects the decrease in subsistence farming and the strengthening of commercial farms and other agricultural organisations fully reliant on hired labour.

Fourth, with the exception of Hungary, there is skill deficiency in Agriculture, Forestry and Fishing sector; the extent of skills deficiency is larger in Greece.

Fifth, rural areas have become more diversified, in particular with a prominent tertiary sector and less reliant on agriculture; agriculture is a minority employer in rural areas of all studied countries.

Fifth, in addition to the CAP, most of the countries have their own schemes either concerning social security and tax system for farming, introduction of minimum wage or implementing measures for stimulation of rural job in sparsely populated regions.

Sixth, with the exception of Greece, there is an upwards tendency in incomes and wages in nominal terms.

4 Analysis of the effect of ecological farming practices on the intensity of labour use [8]

4.1 Objectives, methodological approach and variables

The main objective of this section of the deliverable is to investigate empirically the direct employment effects of ecological approaches to farming. Whilst farm employment has been studied widely, there is no systematic study on the effects of ecological practices on labour use. The policy issue is that labour is a cost to farm businesses which farmers try to minimise. Therefore, if ecological approaches are shown to be more labour intensive, the need to employ more labour on a farm can act as an impediment to farmers to adopt ecological practices. Targeted policy measures may be required to incentivise the adoption since ecological approaches deliver important environmental and social benefits. As indicated in the literature review, there is no theory to lead the researchers to *a priori* expectations about the farm labour effects of ecological practices and, therefore, an empirical study was necessary to achieve the objective of the deliverable.

The main assumption in the deliverable is that there are different socio-economic outcomes of the different farming systems, the latter defined in LIFT conceptual typology, explained in LIFT Deliverable 1.1 (Rega *et al*., 2018) within the continuum from conventional to agroecological farming, and farms either do not implement ecological practices at all or some of those and to a different degree. Therefore, farms are heterogenous according to the implementation of ecological elements and this may affect differently their labour use.

The analysis is carried out at a farm level, employing datasets from the FADN for the period 2004-2015. The five countries participating in this deliverable – Greece, France, Hungary, Poland and England (whole UK in this FADN analysis) - present a mix between Southern, Central European and North Western countries with farms operating under different climate and environmental conditions.

As mentioned, the objective of this section of the deliverable is to investigate the effects of ecological farming approaches on labour use. In doing this, the starting point is that the labour use is part of the overall production technology mix and, therefore, should depend on the use of other inputs and factors of production. Thus, it is logical to expect labour use to depend on the use of farming inputs and capital. However, in practice, all these inputs (including labour) are heterogeneous in nature and are characterised by considerable quality variation, which unfortunately is difficult to either observe or measure. Therefore, in order to reduce the impact of quality differences in the inputs and capital, the monetary value is used to take account of quality differences that would be reflected in price differentials. Then all inputs are standardised by dividing them by the overall output value to remove the effect of different farm sizes. Output value was chosen instead of the physical size of a farm in hectares, which is frequently used, in order to focus the discussion on the way output (and by consequence how food is produced), rather than how land is used. Hereafter, the quantities obtained via this standardisation are referred to as intensities. These intensities express all inputs in similar units and these standard terms preserve their relative importance in the farm input mix. Changes in the intensity of any input, hence, denote changes in the way this input is employed to produce the output and, therefore, will lead to an increase or decrease of the importance of this input in the overall output relationship.

The modelling approach employed in this part of the deliverable considers the intensity of labour as a dependent variable and as a function of the intensities of farming inputs (fuel, fertiliser, crop protection chemicals and capital depreciation), and of AEP. We, furthermore, assume that this model has an additive structure and the effects on labour can be decomposed into separate components derived

[8] UNIKENT LIFT team, which worked on this section, thank to Dr Philip Kostov from the University of Central Lancashire, UK, who advised on the modelling approach.

from the intensities of inputs, capital and AEP. However, it would be unrealistic to assume that this relationship can be reasonably approximated by a linear function. As mentioned previously, our prior Delphi study into the possible effects of ecological practices on labour use, revealed that the underlying issues have a complex structure that may require a more flexible representation. For these reasons a semi-parametric approach was employed in which most additive components contributing to the changes in labour use were modelled nonparametrically while the variable used to control for farm complexity, i.e. the number of farm enterprises (activities), was modelled parametrically.

For this deliverable, the main point of interest is the issue of whether ecological practices affect labour use. There is though no reliable measure for the extent of ecological orientation of a given farm. One option is to consider those farms which are in receipt of larger per hectare AEP since they may be more ecological as they use environmentally friendly practices required by their AES contracts. The short-coming of such an approach is that AEP may underestimate the use of ecological farming since a farm with sound ecological practices may not, for a variety of reasons, participate in AES and may be ineligible to receive such payments. Following LIFT conceptual typology in Deliverable 1.1 (Rega *et al.*, 2018), it is assumed that more ecological farms will be characterised by the production of output with a lower intensity of, predominantly fossil fuel derived purchased inputs, in particular with regard to fertiliser and crop protection chemicals, and potentially, fuel. Furthermore, a low intensity of use of one input may not indicate that a farm uses ecological practices due to the possible substitution of a high intensity use of another input or inputs. In other words, if a farm uses relatively a small amount of crop protection chemicals but a lot of fuel for mechanisation it may not be very ecological. Therefore, the input intensities were combined to derive a measure of the extent of ecological practices for each farm. Although such a measure is not a perfect one, it is clear that all ecological farms must lie at the lower end of this combined input intensity scale and it should, therefore, be possible to distinguish them in qualitative terms. This *combined input intensity* is calculated by simply adding up the intensities of fuel, crop protection chemicals and fertilisers. Since all these are measured in monetary terms (expenditures) they are essentially in the same measurement units and hence could be added together. The effects of the independent variables depend on this input intensity in the sense that these effects may change with input intensity. In practical terms, this means that the effects on intensity of labour use are allowed to change (in a gradual way) with the combined input intensity. The exact pattern of such a change becomes an important analytical issue since it denotes the way such effects vary with the degree of farm adoption of ecological practices. The only exception to the above is the effect of AEP, which is assumed to vary with its own intensity, in other words, the modelling allows the effect of AEP to vary with the extent to which a farm subscribes to such payments, a proxy for participation in AES.

We can therefore express the model in the following general form in equation (1):

$$y = \alpha + \sum_1^k f_i\,(X_i) + u \qquad (1)$$

where $f_i(.)$ are some smooth functions. So, the model for the dependent variable y is simply a sum, 1 through to k number, of smooth functions of the predictor variables, X_i, α is a parameter to be estimated, and u is an error term. The smooth functions above are represented by penalised regression splines (Marx and Eilers, 1998). The degree of smoothness is measured by the corresponding smoothness penalty parameters applied as quadratic penalties. These are automatically selected during estimation using the Generalised cross Validation (GCV) criterion i.e. $\frac{nD}{(n-DoF)^2}$ where *D* is the deviance, *n* is the sample size and *DoF* is the effective degrees of freedom in the model.

In order to make a parallel to the well-known linear (regression) model, we can set $f_i(X_i) = g_i(.)X_i$ and express the above in the following way in equation (2):

$$y = \alpha + \sum_1^k g_i\,(.)X_i + u \qquad (2)$$

This expression bears a close resemblance to the linear model. The difference is that, instead of a fixed (scalar) effect, we have a functional effect $g_i(.)$, i.e. the effect itself is a function that varies in some way. In this generic representation we have not defined the exact way this functional effect is specified, which is a modelling issue. As we have said above, most of these effects are assumed to vary in a smooth manner with the combined input intensity, while the AEP vary with AEP itself. Therefore, we can expand the model specification:

$$y = \alpha + \beta NumEnt + g_1(AEP)AEP + g_2(Ints)Fuel + g_2(Ints)Fert + g_3(Ints)CP + g_4(Ints)K + u \quad (3)$$

where the dependent variable y is the labour use intensity, while *NumEnt* is the number of farm enterprises, AEP, $Fuel$, $Fert$, CP and K are the intensities of AEP, fuel, fertiliser, crop protection and capital respectively, while $Ints$ is the combined inputs intensity (i.e. $Ints = Fuel + Fert + CP$). In $NumEnt$ the crop varieties include the number of different crops that the farm cultivates. The number of different animal types present on the farm are added with the number of different crop varieties. This variable is a control on the complexity of the farming operation and output. K is calculated as the sum of the depreciation value of farm buildings, land improvement and machinery and equipment, as well as total interest paid. α, β are parameters to be estimated, and u is an error term.

The above representation in which the overall effects $f_i(.)$ are expressed as 'functional coefficients' $g_i(.)$ makes the assumed underlying structure much more explicit.

When we estimate the model to obtain estimates of the overall effects $f_i(.)$, which can then be plotted against the quantity with which they vary. For example, $f_2(Fuel)$ will be plotted against the combined input intensity $Ints$ to investigate whether the effect of $Fuel$ does indeed vary with input intensity, which as explained, we use to approximate the extent of ecological farming practices) and if so how exactly. Since $f_2(Fuel) = g_2(Ints)Fuel$ this is the same as plotting the equivalent to a linear model and the observed function $f_i(.)$ will be upward sloping whenever the corresponding functional coefficient $g_i(.)$ is positive and downward sloping whenever $g_i(.)$ is negative. (i.e. $g_i(.)$ is the first derivative of $f_i(.)$.

We also account for data heterogeneity via random effects. The random effects can be represented as straightforward smoothers. In this case random effects are essentially random intercepts for each level of an underlying factor variable. These random intercepts are assumed to be i.i.d. and normally distributed. The i.i.d. normality assumption is equivalent to an identity penalty matrix (i.e. a ridge penalty) on its coefficients, which is the way they can be implemented. Ideally, we would like to account for both farm and time heterogeneity. Including random effects for both farms and time however results in identification issues. For this reason, we include a conventional random effect for farms and add to it a time varying farm effect, similar to the main interaction effects. The main difference is that since we have two types of farm effects when constructing the tensor product bases for the time-farm interaction, we remove the bases that are associated with the 'pure' farm random effect. Therefore, the final model specification can be represented as:

$$y = \alpha + \beta NumEnt + g_1(AEP)AEP + g_2(Ints)Fuel + g_2(Ints)Fert + g_3(Ints)CP + g_4(Ints)K + h_0(farm) + h_1(year * farm) + u \quad (4)$$

We use a different notation, namely $h_i(.)$ to denote the two types of random effects since $farm$ and $year$ are factor variables and are, therefore, treated differently to the numerical variables in the rest of the model. α, β, g, h are parameters to be estimated, and u is an error term.

The information derived from our qualitative Delphi study revealed that the underlying issues have a complex structure, thus to model the relationship between the combined input intensity and the measure of intensity of labour use as a linear function might not be appropriate. Therefore, a semi-parametric approach has been adopted. In the estimations the additive components contributing to the changes in labour use have been modelled non-parametrically, and the control variable - number of farm enterprises - has been modelled parametrically.

4.2 Data

FADN datasets for the five countries cover the period 2004-2015 (the period for which data was made available in LIFT). Data was cleaned for occasions in which there were negative values for any of the variables concerned. Since conceptually some measures such as output, number of farm enterprises and total labour do not admit zero values, any observations which recorded such zero values were also deleted. Some of the extreme observations in individual intensities have been removed. The rationale for this is the following. All intensities, apart labour, are expressed as ratios to output value with numerators in monetary terms. Conceptually, it is helpful to think of these as potentially ranging from 0 to 1, particularly since this would facilitate comparisons between both countries and individual intensities. Technically, however, it is feasible that any individual intensity can exceed 1, particularly if the input under question has a low added value with regard to the final output. Such high intensity values were relatively uncommon in the data, but in the few cases when they existed they were removed from the estimation sample[9]. These farms with very large intensities are quite far from what it can be considered as farms implementing ecological farming practices and, therefore, far from the core of the interest in this deliverable.

Table 2 below presents the number of farms and observations, the latter are for the whole analysed period after the cleaning process.

Table 2: Number of farms and observations per country in FADN data (2004-2015)

	Greece	France	Hungary	Poland	UK
Number of farms	7,912	14,946	3,368	23,899	5,766
Total observations	45,628	83,654	21,820	135,312	29,423

[9] In terms of the type of model used here, i.e. semi-parametric, such extreme values do not present such a challenge as outliers usually do in parametric models. Therefore, we could have retained them and then simply exclude the effects associated with such extreme intensities from the results presentation. Here we have opted to exclude them from the estimation sample itself which allowed for common treatment of the model estimation and results presentation.

Table 3:Number and share of observations by type of farming (TF8) and country in FADN data (2004-2015)

TF8	Descrip-tion	Greece		France		Hungary		Poland		UK	
		No	%	No	%	No	%	No	%	No	%
1	Field crops	20,361	44.6	19,552	23.4	11,227	51.5	28,941	21.4	5,342	18.2
2	Horticul-ture	1,295	2.8	4,955	5.9	1,108	5.1	4,822	3.6	1,507	5.1
3	Wine	2,382	5.2	12,330	14.7	707	3.2	0.0	0.0	1.0	0.0
4	Other Per-manent Crops	11,131	24.4	3,996	4.8	1,341	6.1	3,921	2.9	458	1.6
5	Milk	139	0.3	12,984	15.5	1,265	5.8	27,874	20.6	5,845	19.9
6	Other Grazing Livestock	6,508	14.3	14,588	17.4	772	3.5	2,902	2.1	11,694	39.7
7	Granivores	143	0.3	4,531	5.4	2,378	10.9	15,125	11.2	1,682	5.7
8	Mixed	3,669	8.0	10,718	12.8	3,022	13.8	51,727	38.2	2,894	9.8
	Total	45,628		83,654		21,820		135,312		29,423	

Table 3 indicates that the importance of types of farming varies substantially between countries. From the point of view of ecological farming, the most important are mixed farms, which are included in the integrated farming systems cluster of ecological farming, defined by Rega *et al*. (2018). Mixed farming is by far more prevalent in Poland in comparison to the other countries analysed. The high proportion of other permanent crops in Greece is a result of the large olive sector in the country.

For the analysis in this deliverable, the relation between family labour (unpaid labour as labelled in FADN) and hired (paid labour) is important to contextualise the analytical results. It is presented in Table 4. Although everywhere labour is predominantly family, Hungary has a larger share of hired labour. As indicated in the countries overview, there was substantial rebalancing between family and hired labour in Hungary due to the disappearance of many subsistence farms and development of commercial farming reliant on hired labour.

Table 4: Family and hired labour per country

	Greece	France	Hungary	Poland	UK
Share Family (%)	0.88	0.77	0.62	0.94	0.80
Share Hired (%)	0.12	0.23	0.38	0.06	0.20
Hired >0.5: No of observations	2,691	16,391	9,191	8,161	6,635
Hired >0.75: No of observations	278	5,448	6,069	3,241	2,720

4.3 Results of FADN analysis

The results are presented in the figures in Appendix 1[10]. The effect associated with any variable is plotted against its source of variation. An upward sloping curve in the plots shows a positive effect, while a downward sloping one reveals a negative effect on labour use intensity.

First, a comparison between the five MSs according to each input intensity is discussed. Looking at figures 2-6 in Appendix 1, which present the comparison between the five EU MSs per input, it can be observed that the relationship between labour, and input and capital intensities is very similar across the countries. When input intensity is low (what is a proxy for a farm implementing ecological approaches to agriculture), adding more inputs increases the intensity of labour, in other words the labour composition of output is increasing and possibly creating jobs, but beyond some threshold, which differs between countries, the labour intensity begins to decline. Therefore, at a high input intensity, which is a proxy for conventional farms, inputs displace labour.

Although the results indicate similar overall effect of inputs on labour, the threshold at which the relationship between input intensity and labour intensity switches from complementarity to substitutability varies at different countries. The observed switches at the extremely low input intensities are due to very small numbers of observations and are not taken into consideration.

A more detailed look at the thresholds is presented in Table 5. In general, the turning points of the combined intensities in the five countries analysed are at similar values.

Table 5: Turning points of combined input intensity from complementarity to substitutability with labour

	France	Greece	Hungary	Poland	UK
Crop Protection	0.145	0.16	0.23	0.10	0.125
Fertiliser	0.175	0.22	0.20	0.20	0.16
Fuel	0.085	0.22	0.31	0.151	0.12
Capital	0.42	0.51	0.49	0.39	0.45

Concerning crop protection chemicals (Figure 2), in Greece, France, Poland and the UK the switch from complementarity to substitutability is around a combined input intensity of 0.1 to 0.16. Hungary is different in a sense that the threshold is higher at 0.23. For fertiliser (Figure 3) the switch to a fall in labour intensity is found in the UK and France at a lower intensity in comparison to the other countries, i.e. at approximately 0.16 to 0.17, whilst in the other three countries the intensity is around 0.20 and above. The increase of labour input in ecological farming approaches, which in our case are proxied by low fertiliser and crop protection intensities, is supported by Nguyen and Haynes (1995) who used three pairs of mixed farms in which one was conventional and the others under an alternative system – either organic or biodynamic. They followed the farms over the whole rotation period of several years. Their results show that labour input for individual cereal crop production was higher under alternative than conventional farming management, but since they were investigating the whole rotation period and the alternative farming systems involved longer rotation which contained several years of grazed leguminous pasture, as expected, during this phase less labour was needed. As a result, when

[10] Model summaries are available from UNIKENT team.

considering the overall rotation period, on average, labour input was lower in alternative than in conventional systems. For fuel (Figure 4) France and the UK have much lower thresholds – this may mean that the positive effect on labour use of low or minimum tillage dissipates very soon after the use of mechanisation increases. In the other three countries the substitution of mechanisation for labour also appears but at a higher combined input intensity. These results support the effect of ecological farming. At a low intensity, these results suggest that more labour is required. For example, if a farm is less fuel intensive, this might mean that the technology requires either smaller machinery and, thus, more hours of machinery drivers or substitution of manual work for mechanisation. Higher fuel intensity requiring less labour input exemplifies conventional farming. De Wit (1979) focussed on the use of fossil energy and conceptualised the problem that different agricultural systems may be defined as transformation of tradable (internationally) fossil energy into tradeable agricultural products by means of untradeable labour (and land). He argues that energy and labour are substitutes which in this deliverable is found in high fuel intensive farms, thus, conventional farms. The substitution of capital for labour appears at roughly the same threshold in all countries between 0.4 and 0.5 (Figure 5). This suggests that the substitution effect appears at relatively high capital content of the output. Therefore, the substitution effect is clearly prevalent in capital-intensive technologies.

In terms of assessing farm technical-economic performance relating to changes in labour use - a lower intensity of input use relative to output indicates an ecologically less intensive farm, but it is also a farm that is potentially more productive and profitable. As an ecological farm uses more of an input, its labour share of output increases where the labour input increases by more than the output share.

The relationship between the intensities of AEP and labour is different and requires a different interpretation. The *a priori* expectations were that the AEP intensity should increase labour intensity, since AEP can be thought as an indicator of the environmental sustainability of the farm. Based on the literature review the expectations were also that farms may increase their capture of AEP while compromising commercial farm output only marginally. This means that, concerning AEP intensity, the numerator may increase at a greater rate than the denominator. Figure 6 presents an almost linear relationship - in all the countries the increase of intensity of AEP can boost the relative use of labour. Mettepenningen *et al*. (2009), based on a survey in nine EU MSs (covering either the whole country or selected regions), report that when a minimum critical mass is achieved, meaning that when farms need to fulfil more environmental tasks, this translates into higher labour intensity. The same study emphasised two types of costs requiring more labour input – private transaction costs and field costs. Concerning the private transaction costs during the AES implementation, farmers listed costs for e.g. registering fertiliser use and information search. With respect to field work, respondents argued that additional labour was necessary for extra tasks required by the AES contract, such as sowing a cover crop, planting hedges, building fences and walls, and extra work to cope with weeds as a result of reduced pesticide usage.

Whilst the above results refer to total labour use, it is important to look at the difference in the effect of inputs on the relative use of family and hired labour respectively in each country. The results are presented in Figures 7-11 in Appendix 1. In the figures the blue, solid line indicates the effect on total labour intensity, the black, dashed line on family and the red, dotted line on hired

For all countries, the picture seen in total labour is closely mirrored by that of family only labour with the exception of the overall level of curve because family labour is only part of total labour. The peak of family labour share is, therefore, lower than that of total labour. However, both curves peak at the same input intensities. The close similarity of these curves reflects the high importance of family labour in the share of all labour used on the FADN farms (refer again to Table 5). The estimated response curve for hired labour intensity has a far flatter profile that that of farm family labour. In practice, this result means that as a technological change towards more ecological practices such as agroecology alters output, it is hired labour that can more flexibly adjust the working hours up or down, due to more or less individuals hired, to the necessary labour content of output. Family labour seems more rigid. As farming practices change, family labour may not be able to alter enough to compensate for a change in the denominator, output, because the number of individuals supplying labour is relatively fixed and certainly predetermined. Exogenously determined family members can only change working hours, and only occasionally may family labour switch from unemployment or other employment to working on farm. Even though the market for hired labour includes notable transactions costs and contract restrictions, these results suggest that farms may have higher flexibility in hired labour employment. Therefore, and even in Hungary where the hired labour curve is less flat in comparison to the other countries, adjusting hired labour appears to have more latitude than adjusting family labour. This means that ecological approaches to farming may mainly increase the use of hired labour.

As previously stated, the number of enterprises was used as a control variable proxying the complexity of output and a more integrated farming system, as classified by Rega *et al*. (2018). Parametric coefficients (β in equation (4)) were always significant (Table 6). This indicates that the increased complexity of output, which is expected to be present in the farms using ecological farming practices, results in higher labour intensity.

Table 6: Effect of number of enterprises on labour use

Country	Coefficient	T-statistic
Greece	1.358	92.57***
France	1.156	156.6***
Hungary	2.544	96.67***
Poland	4.413	413.2***
England	2.52	185.5***

Note: Coefficients are scaled by a factor of 10^{24}

****: significance at 1 per cent*

4.4 Conclusions on the analysis of labour effects

This part of the deliverable quantifies the labour use effects of ecological approaches to farming, employing management data from FADN.

The estimation results show a similar pattern in all the countries – low input and capital intensity increases the intensity of labour use as more purchased inputs are used. However, there is a tipping point when inputs and capital become substitutes for labour. The pattern is identical amongst countries but the tipping point is country-specific. These results suggest that farms which use ecological farming practices may use less labour as they use fewer purchased inputs. Therefore, policies which support the adoption of ecological agriculture may have as a by-product increased (maintained) farm, and consequently, rural employment. (This, however, might be true only in short- to mid-term since technological change with wider introduction of precision agriculture, AI, robots may bring simultaneously a decrease in farm labour use and wider adoption of ecological farming practices). However, if farmers are reluctant to adopt ecological farming practices trying to minimise labour costs, policy incentives are necessary to stimulate adoption which can potentially provide important environmental and social non-product benefits.

In all five EU MSs the AEP increase labour use. This is an interesting result, bearing in mind that concerning agri-environmental policy the EU CAP includes a greater flexibility allowing MSs to design and implement their own programmes. This result implies that non-product output, produced by farmers participating in AES appears to increase labour intensity.

As farming practices change, family labour may not be able to alter enough to compensate for a change in the labour content of output, because the number of individuals supplying labour is relatively fixed. Exogenously determined family members can only change working hours, and only occasionally may family labour switch from unemployment or other employment to working on farm. Adjusting hired labour appears to have more latitude than adjusting family labour. This means that ecological approaches to farming will mainly increase the use of hired labour (or external contracting, which is also a flexible source of labour).

Government policies, which concerning labour market in agriculture have mainly focused on minimum wage and social insurance, have to be re-orientated towards decrease of transaction costs allowing more flexible adjustments of hired labour in view of wider adoption of ecological farming practices. Some steps in this direction exist although they still do not have the expected results due to other factors that act as barriers. One example is the simplified employment scheme in Hungary which increases farmers flexibility to hire seasonal workers and decreases the transaction costs. However, since the scheme is restricted to hired labour which will not work on farm for more than 120 days/year, the lack of other rural jobs substantially limits the demand by potential farm workers. Further research should focus on a comparative study of best practice in the EU since it may provide important policy insights on how to build more flexibility in the market for hired farm labour.

5 Analysis of the returns to skills in ecological farming based on LIFT large-scale farmer survey

Whilst the focus in the previous section was on the quantity of use of labour depending on the intensity of use of external purchased inputs and the receipt of AEP, the focus of this analysis is on the returns to skills of different approaches to farming. The objective of this section is to analyse the skill requirements and returns to skill in a range of farming techniques which contribute toward ecological agriculture.

The adoption of new techniques or technologies of production and their effective employment requires skills - skills 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 the employment of these skills for economic gain. The *a priory* expectations are 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. OECD (2016, p.12) underlined that “skills mismatch implies costs for workers, employers and the economy. For workers, it brings about lower wages and lower job satisfaction. For the economy, it entails lower economic output. Skills shortages increase hiring costs and lower productivity”.

The data used in this section is from the LIFT large-scale farmer survey (see questionnaire in Deliverable 2.2, Tzouramani *et al.,* 2019) and only covers the case study areas covered by the survey. First some short overview of these areas is presented.

5.1 Short overview of the LIFT case study areas

5.1.1 French case study[11]

This study is implemented in two areas in France, namely NUTS2 region Brittany (in Western France) and NUTS3 region Puy-de-Dôme which is part of NUST2 region Auvergne (in Central France)[12]. The 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 per cent in 2010 compared to 10.2 per cent nationally). The UAA in this region represents 62 per cent of the whole regional area (50 per cent at the national level). Brittany is the most important region in terms of agricultural production, particularly for fresh vegetables (83 per cent of cauliflower production) and animal production (58 per cent of pigs, 42 per cent of laying hens, 21 per cent dairy cows). The agri-food industry accounts for around a third of industrial jobs in the region (around 68,000), i.e. 6.51 per cent of total number of jobs in the region (compared to 2.44 per cent in France). Brittany has 32,150 farms but between 2000 and 2010 the number of farms decreased by 32 per cent, thus with a higher rate than in metropolitan France (26 per cent).

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 per cent in 2018) compared to the tertiary sector (representing 34.5 per cent of employment, vs. 30.6 per cent at national level). Rural areas represent 69 per cent of the overall regional area, although agricultural productivity is rather low and located mainly in less favoured areas (€13,158 per AWU in Auvergne vs. €36,894 per AWU at national level). The agri-food sector represents 2.7 per cent of regional jobs, mainly in the dairy and meat sectors (6 jobs out of 10).

[11] The French case study data presented in this deliverable are for 2016, and originate from the French National Statistical Office (INSEE) and the French Ministry of Agriculture (Agreste): https://www.insee.fr/en/accueil and https://agreste.agriculture.gouv.fr/agreste-web/

[12] ‘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)

Most farms (70 per cent) are located in mountainous areas and approximately 75 per cent 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 per cent 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 per year per AWU vs. €30,000 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 (NUTS 2) 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 fertilisation, 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 in AES for conversion to organic farming.

5.1.2 Greek case study

The study is implemented in Crete, which is the largest and most populated island of Greece with 623,065 inhabitants, located approximately 160 km south of the Greek mainland and covers an area of 8,336 km^2. Out of those, approximately 188,118 ha are covered by olive oil trees, when the respective area for the whole of Greece is approximately 792,642 ha (HSA[13], 2017). In fact, in 2017, Crete accounted for 23.4 per cent of the total country's olive oil production, out of which 71.7 per cent was produced in the regional units of NUTS3 Heraklion and Lasithi (the two case study areas surveyed in this study) (HSA, 2017).

In the Greek olive oil sector, the most commonly met quality schemes are the organic certification according to the EU legislation on organic farming, GI label and AGRO 2 (AGRO 2.1 & AGRO 2.2/3 which is specifically targeted on olives). AGRO 2 is the national quality label for implementation and certification of the Integrated Management System in agricultural production. Furthermore, in 2017 approximately 50,085 ha were occupied by organic olive trees, including olive groves that were in the process of converting to an organic farming system (Duvaleix *et al.,* 2020). In the study area of Eastern Crete, in the regional units of Heraklion and Lasithi, there were nine organic certification bodies in 2017 and 736 organic producers with an area of 3,722 ha of organic olive trees in Heraklion and 290 organic producers with an area of 868 ha in Lasithi (Duvaleix *et al.,* 2020). According to the EU's Database of Origin and Registration (DOOR), Greece has 30 registered geographical indication (GI) labels for olive oil (19 protected designation of origin-PDOs and 11 protected geographical indications-PGIs), out of which 11 cover the region of Crete (10 PDOs and 1 PGI). To be more precise, five of the PDO olive oils are produced in the regional unit of Heraklion and one in the regional unit of Lasithi. Lastly, in 2017, there were 2,508 AGRO 2 certified producers in Heraklion and 2,658 in Lasithi, where the area covered was 6,623 ha and 5,422 ha respectively (Duvaleix *et al*., 2020).

Crete also constitutes one of the country's major viticultural centres. The total area of land covered by vines in Crete was about 18,086 hectares (ha) in 2018, representing approximately 20% of Greece's total area under vines (89,246 ha) (HSA, 2018). In particular, the area under grapes for wine

[13] Unless otherwise stated, statistics in the Greek case study presented in this deliverable are from the Hellenic Statistical Authority, https://www.statistics.gr/en/statistics/agr

in Crete was around 6,185 ha in 2018, of which the case study areas, Heraklion and Lasithi, accounted for 49% and 13% respectively (HSA, 2018).

In 2017, the area covered with organic vineyards in Heraklion was approximately 271 ha, corresponding to 157 organic producers and 56.4 ha with 30 organic producers, respectively, in Lasithi, (Tzouramani *et al.,* 2019).

Changes regarding total sectoral employment were observed in the regional unit of Heraklion between 2005 and 2016, with a decrease in the number of holders and their household members employed in the holding, seasonal workers" and "employment in mutual help between farmers by 11.95 per cent, 30.30 per cent and 48.28 per cent respectively. In contrast, the number of permanent workers underwent an increase of 29.23 per cent. Similar changes were observed in the regional unit of Lasithi, between 2005 and 2016, with a decrease in the same respective categories 18.91 per cent, 22.1 per cent and 22.2 per cent and again in contrast, the number of permanent workers underwent an increase of 33.27 per cent.

5.1.3 Hungarian case study[14]

The two Hungarian case study areas are located in the two extremes of the country with rather different geographical, geological and agricultural characteristics.

Hajdú-Bihar county (NUTS3) is located in the Eastern part of Hungary, at the Romanian border, with Debrecen as the county capital. It is the fourth largest Hungarian county. Geographically, the region is in the Hungarian Great Plain, a flat, agricultural region. Most of its territory belongs to the river Tisza basin, important for its water supply for agriculture. The area is 6,211 km^2 with a population density of 84.8 inhabitants/km^2. As a comparison, the population density of the entire country is 105 inhabitants/km^2. The agricultural area is 544,000 ha with 334,000 ha arable land. The total area of the county is 621,000 ha; thus, it is an evidently prominent agricultural region. Some data with respect to the production structure emphasise its importance: 169,000 ha are used for cereals, 523 ha for grapes, it produces annually 43,800 tons of fruits, 110,000 cattle heads, and 459,000 pigs. Besides agriculture, industry is also present, e.g. the Daimler-Benz plant in Debrecen. Unemployment rate is higher than the national average, at 5.2 per cent. With respect to the wages, whilst national average monthly wage is 268,000 Hungarian Forint (HUF), wages in Hajdú – Bihar county are lower, at 218,000 HUF.

Veszprém county (NUTS3) is in the West part of Hungary, in the Western Transdanubia region. The case study is a hilly region, the Bakony mountains occupy the middle of the county. The area of the county is 4,464 km^2, with a population density of 76.42 inhabitants/km^2. In the 1980s it was heavily industrialised, mostly due to the local mining of mineral resources. Further, chemical industry still provides important employment. Unemployment rate is lower than the national average, 2.8 per cent. Average wages in the region are somewhat lower than the national monthly average but higher than in Hajdú-Bihar (240,000 HUF). The region provides generally unfavourable conditions for agriculture, except viticulture. Some of the most notable wine production areas are located on the western shores of Lake Balaton. The county's agricultural production structure is: 61,000 ha cereals, 4,156 ha of vineyards, 6,288 tons of fruit, 517,000 cattle heads, and 118,000 pigs.

5.1.4 Polish case study[15]

Lubelskie Voivodeship (NUTS2) is located in the south-eastern part of Poland bordering Belarus and Ukraine to the east covering an area of 25,155 km^2. The Gross domestic product (GDP) of the province

[14] The Hungarian case study data presented in this deliverable are for 2020, and originate from the Hungarian Central Statistical Agency, www.ksh.hu

[15] The Polish case study data presented in this deliverable are from Statistics Poland. Yearbook of the Regions – Poland. Warsaw 2019. https://stat.gov.pl/obszary-tematyczne/roczniki-statystyczne/roczniki-statystyczne/rocznik-statystyczny-wojewodztw-2019,4,14.html

was €18.5 billion in 2018, accounting for 3.7 per cent of Polish economic output. GDP per capita adjusted for purchasing power was €14,400 or 48 per cent of the EU27 average in the same year. More than half of the regional population (almost 1.2 million people) live in rural areas and as much as 37 per cent of working people engage in agriculture compared to the country average of 16 per cent. There are about 18,500 farms, 80 per cent are very small, up to 10 ha. Lubelskie's agricultural area is known as the food granary of Poland. This is one of the three best regions in Poland for water conditions, soil quality, agro-climate and landform. Farmers in Lubelskie specialise in crop production, while livestock production is mainly pork (54 per cent) and cow milk (37 per cent). The region dominates national soft fruit production, producing around 200,000 tons per year and is the second largest producer of tree fruit in the country. Ecological farming in Lubelskie is growing, currently constituting an area of 34,000ha and as of 2015 there were 1,896 certified organic producers. Organic production in the area is the highest nationally with 11,000 tonnes of fruit and 5,000 tonnes of vegetables produced per year (20 per cent and 17 per cent respectively of nationwide production).

The second case study area Podlaskie is a NUTS2 region in north-eastern Poland. It borders other Polish regions to the west, northwest and south, Republic of Belarus to the east, Lithuania to the northeast and the Kaliningrad Oblast of Russia to the north. Podlaskie has a varied landscape with vast forests and numerous lakes, ca. 30 per cent of the area is under legal protection. Podlaskie has the lowest population density (59/km^2) of the sixteen Polish regions, and its largely unspoiled nature is one of its main assets. Agriculture in Podlaskie Voivodeship functions in harsh natural, both climatic and soil conditions – a very short vegetation period, record low temperature, poor soil and periodic water deficits. Despite this, there are over 100,000 farms in the region, average farm size being around 13 ha. The area is suited to producing milk and beef; whilst concerning crops, potatoes, cereals and sugar beet are also cultivated. Agrotourism is a growing enterprise for farms in the area. Other industries that are of major importance to Podlaskie include: food processing, light industry, wood industry and the production of machines. The most dynamic development is observed in the production of food. The plants operating within this sector specialise in the processing of milk, meat, poultry, as well as cereal and beer making. Large and modern dairies located in Podlaskie are famous for their excellent products in all of Poland. Light industry is responsible for the production, firstly, of many different kinds of fabrics, carpets and fleece products. The essential economic sector in the region is the wood processing industry supported by local raw materials.

5.1.5 English case study

Both English case study areas (North Kent and High Weald) are located in South East England – the most populous region in the UK with approximately 9.2 million inhabitants, 13.7 per cent of the UK total, and very densely populated at 481 inhabitants/km^2 against a UK average of 275 inhabitants/km^2 (ONS, 2020b). Unemployment in the region in 2019 was equal to 3.2 per cent which was slightly below the UK average of 3.9 per cent (ONS, 2020c).

The case study area of North Kent, covering parts of NUTS3 regions East Kent, Kent Thames Gateway, Medway, Mid Kent and West 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 is typical in the Great Thames Estuary and mixed farming is widespread on the North Downs.

In contrast, the other case study area in the High Weald, covering parts of NUTS3 regions East Sussex and West Kent, 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 per cent) 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 per cent less than 20 ha versus 43 per cent in North Kent) while there are a significant number of farms in North Kent larger than 100 ha (25 per cent versus 14 per cent in the High Weald). Compared to the High Weald, North Kent has a far larger proportion of cereal[16] farms (26 per cent against 10 per cent), but a much lower importance of grazing livestock (30 per cent against 53 per cent).

5.2 Methodological approach

The starting assumption in this aspect of the deliverable 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 this deliverable, data records of the highest level of education attained by the decision maker and other family workers are used, 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 of most interest (skills) is unobserved, the chosen 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, across the decision maker and working family members on the farm, as shown by equation (5).

$$T_f = \beta_0 + \beta_1 Exp_f + \beta_2 Exp_f^2 + \beta_3 Edu\_level_f + \beta_4 Edu\_agri_f + u_f \qquad (5)$$

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; $\beta_{0,\dots,4}$ are parameters to be estimated ; and u_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 (5) 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 in the direction of more ecological practices, e.g. agroecology.

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 and 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 and Fuetsch (2016) argue that a farm's sustainability decreases with

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

farmer's age as older farmers tend to follow traditional approaches; Exp_f^2 is included to control for this life cycle effect.

Equation (5) is estimated with a Probit model. Fitted values from equation (5) 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 other words, they represent a farm's innovative capacity. In the second stage of the empirical strategy, these fitted values are included as skill proxies in equation (6) designed to estimate the returns to skill:

$$\frac{R_f}{L_f} = \delta_0 + \delta_1\widehat{T_f} + \delta_2 L_f + \delta_3 K_f + \delta_4 C_f + \omega_f \qquad (6)$$

where $\widehat{T_f}$ is the fitted value from equation (5); R_f is a measure of either farm revenue as used in four of the countries studied (revenue here comprises revenue from crop, livestock and agricultural products as well as 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 (returns 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 returns to labour; due to the non-availability of capital information in the survey data, it is proxied here with UAA; C_f are other control variables, e.g. case study area, type of farming; $\delta_{0,\ldots,4}$ are parameters to be estimated; and ω_f is an error term.

Equation (6) is estimated with Ordinary Least Squares.

5.3 Data from the LIFT large-scale farmer survey used here

The data used in this analysis were collected through face-to-face interviews during autumn 2019 and spring 2020 based on the LIFT large-scale farmer survey (see Tzouramani *et al.,* 2019 – LIFT Deliverable 2.2) 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 159 farms in the French case study, 105 farms in Greece, 120 farms in Hungary, 100 farms in Poland and 55 farms in the England case study. The French farms include specialist dairy, specialist beef and mixed livestock farms - a mix of dairy and beef cattle. In Greece, the sample is predominantly made up of horticultural farms – comprised of specialist olive growers, and in Hungary of field crop farms. The Polish and English samples cover a wider range of types of farming which reflects the varied agricultural landscape in the case study areas (Table 7).

Table 7: Farms' production specialisation (types of farming) in the survey sample used

	Number of farms in France case study	**Number of farms in Greece case study**	**Number of farms in Hungary case study**	**Number of farms in Poland case study**	**Number of farms in England case study**
Dairy farms	108			17	3
Cattle farms	42			10	11
Mixed livestock farms	9			3	4
Field crop farms			114	20	15
Horticulture farms		35	6	12	9
Mixed crops		70		3	
Mixed crops and livestock farms				26	10
Sheep farms				1	3
Pig farms				8	
All farms	159	105	120	100	55

Tables 8 and 9 provide descriptive statistics of the five sub-samples used. The five sub-samples have slightly different measures of the ecological technology (T_f) - the English and French sub-samples both consider T_f=1 for farms that receive AEP and/or are organic since they are a relatively large portion of the sub-sample. Meanwhile the Greek sub-sample uses only organic, i.e. T_f=1 if the farm is organic, 0 if not. The Hungarian and Polish sub-samples have a T_f=1 if the farm uses conservation or zero tillage techniques and 0 if not. In the Polish and Hungarian sub-samples organic farms have a small share and, therefore, these were not used as their T_f. AEP were not measured in the Greek or Hungarian sub-samples.

As shown in Tables 8 and 9, in terms of farm experience of family members, it is highest in the English sub-sample, followed by the Greek, then Hungarian, French and the lowest average experience is in Poland. General education is noticeably very low in the French sub-sample, although agricultural education is the highest out of the studied countries, indicating that the French farmers tend to opt for agricultural courses rather than having a broader education. The studied English farms also seem to opt for agricultural courses instead with a relatively high rate of agricultural education and a lower general education compared with Greek, Hungarian and Polish farms. The Hungarian general education level is very high with nearly all sampled farms having a family member with a general education and roughly half the farms having an agricultural education. Meanwhile the Polish farms have relatively high levels of both forms of education; the Greek sampled farms have over half of their farms with family members having general education but comparatively the lowest share of farms with agricultural education.

In terms of the remaining variables, labour is highest on Hungarian farms where there too is a high rate of hired labour as a proportion of total labour. The English sample also has a relatively high level of labour use reflecting a high number of horticultural farms whereas Greece has the lowest labour use which may reflect the small farm sizes. Next set of variables - capitalisation, the English farms are most highly capitalised which may reflect the large number of field crop farms that typically require more mechanisation. Turnover (in France) and revenue (elsewhere) is the highest in England and the lowest in Poland. The returns to labour, where turnover or revenue is divided by the number of hours worked, follows the same pattern – very high in England and lowest in Poland.

Table 8: Descriptive statistics of the French and English survey sub-samples

	Descriptive statistics for the French sub-sample			Descriptive statistics for the English sub-sample		
	Number of observations	Mean or share of farms (per cent)	Standard deviation	Number of observations	Mean or share of farms (per cent)	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 (per cent)	146	8	15	55	38	32
Farm capital value (K_f) (€)	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 (England) (€)	121	260,102	246,996	55	662,351	953,982.1
Returns to labour (R_f/L_f) (€/ hour)	111	44.51	32.53	55	74.73	85.2948
Dairy (France)/field crop (England) 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

Table 9: Descriptive statistics for Greek, Hungarian and Polish survey sub-samples

	Descriptive statistics for the Greek sub-sample			Descriptive statistics for the Hungarian sub-sample			Descriptive statistics for the Polish sub-sample		
	Number of observations	Mean or share of farms (per cent)	Standard deviation	Number of observations	Mean or share of farms (per cent)	Standard deviation	Number of observations	Mean or share of farms (per cent)	Standard deviation
Share of farms with ecological technology ($T_f = 1$)	105	0.41	0.05	120	0.33	0.47	100	0.14	-
Share of farms with organic farming	105	0.41	0.05	120	0.02	0.13	100	0.07	-
Share of farms with AESs other than organic farming	-	-	-	-	-	-	100	0.06	-
Farm experience proxy (Exp_f) (years)	105	29.98	1.27	118	26.30	11.76	89	23.27	9.98
General education proxy (Edu_level_f) (dummy)	105	0.58	0.05	120	0.98	0.13	93	0.69	0.47
Agricultural education proxy (Edu_agri_f) (dummy)	105	0.15	0.04	120	0.48	0.50	93	0.60	0.49
Farm total labour (L_f) (hours)	105	1,938.30	243	120	25,785	56,339	84	5,866.7	4,147.1
Share of farm total labour from hired workers (per cent)	-	-	-	120	89.19	-	9	0.005	0.002
Farm capital value (K_f) (€)	105	18,358	2,839	-	-	-	41	251,301.4	437,583.3
Farm cattle herd size (K_f) (livestock units)	-	-	-	-	-	-	100	2.43	8.97
Farm UAA (K_f) (ha)	105	7.62	1.64	120	331.61	491.56	100	15.07	14.89
Farm revenue (R_f) (€)	105	69,491	39,493	-	-	-	90	34,476.75	101,365.4
Returns to labour (R_f/L_f) (€/ hour)	105	34.91	24.92	-	-	-	80	18.33	69.16
Mixed farm (Poland)/olives (Greece) specialist dummy (C_f)	105	0.56	0.05	-	-	-	100	0.26	0.44
Regional dummy (C_f)	105	0.58	0.05	120	0.5	-	100	0.49	0.50

5.4 Discussion of the results: a comparison between the countries

Table 10 displays the results from the first-step estimation, namely equation (5) with the ecological technology dummy as the dependent variable. The estimation for the Hungarian sub-sample produced no significant results; analysis for this case study is shown as pairwise mean equality tests of a change in technology on different labour variables as shown in Appendix 2. These pairwise tests tested if the mean hours for total, family and hired labour, the mean number of years' experience, the mean age, and the mean wage were significantly different between farms using conservation tillage and those that were not (the sample was mostly cereal farms). Results show some significant differences between the number of family hours worked – a greater number of hours in the conservation tillage group. Other results show a significant difference in the wage between the group using conservation tillage and the one that does not. The estimation on the Greek sub-sample produced significant results using a variant estimation with interactions between both forms of education and experience. Results indicate that agricultural education is shown to increase the adoption of ecological practices, but experience interacted with agricultural education decreases the adoption probability. In Poland, experience seems to drive the adoption probability of the ecological technology.

As it could be expected, a high level of general education increases the probability of using the ecological technology for the English sub-sample, as well as agricultural education but the latter with lower level of significance. By contrast, general education in Poland has a negative impact, and in France the impact of both forms of education is negative, which is 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 participation in France. Chabé-Ferret and Subervie (2013) found that participants are more educated than non-participants, using data from the 2000 French Agricultural Census. In contrast, Dakpo *et al*. (2021) analysing dairy farms in the French FADN 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 an AES participant. The farms in the French survey data used in this deliverable 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 11 shows results from the second-step estimation, namely equation (6) with the revenue per work hour as the dependent variable (turnover per work hour in France), a proxy for wage, and the fitted-value from equation (5) as an explanatory variable measuring the capacity of a farm to innovate into an ecological technology using its level of human capital. As expected, the quantity of labour on farm has a negative impact on the returns to labour, while assets (capital value, herd, land) have a positive impact (or no effect). The results vary substantially country by country.

Again, the results for the Greek sub-sample are all insignificant. In the Polish sub-sample, the fitted value is not significant. Skill proxy is positive in the regression on the English sub-sample, suggesting that this skill level enables higher returns 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 a loss. This may come from the fact that both high general education and high agricultural education have a negative impact on ecological technology used 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, apprenticeship or specialised courses. 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 returns to labour (the French sub-sample consists of livestock farms only).

Table 10: Results from the first-step equation (5) with the ecological technology dummy as dependent variable

	Results for the French sub-sample	**Results for the English sub-sample**	**Results for the Greek sub-sample**	**Results for the Polish sub-sample**
Farm experience (Exp_f)	0.025 (0.045)	0.000 (0.064)	-0.038 (0.045)	0.428*** (0.167)
Farm experience squared (Exp_f^2)	-0.000 (0.001)	0.000 (0.001)	-0.000 (0.001)	-0.008*** (0.003)
General education (Edu_level_f)	-0.613** (0.0309)	1.072** (0.501)	0.635 (0.679)	-0.706* (0.409)
Agricultural education (Edu_agri_f)	-0.887** (0.354)	0.913* (0.551)	1.518* (0.896)	0.294 (0.393)
General education and experience interaction ($Edu\_level_f \# Exp_f$)	-	-	-0.008 (0.021)	-
Agricultural education and experience interaction ($Edu\_agri_f \# Exp_f$)	-	-	-0.064** (0.029)	-
Intercept	0.430 (0.632)	0.154 (0.423)	-0.900 (0.021)	-6.115*** 2.264
Pseudo R-square	0.049	0.094	0.019	0.180
Number of observations	152	55	105	87

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

Table 11: Results from the second-step equation (6) with the returns to labour as dependent variable

	Results for the French sub-sample	Results for the English sub-sample	Results for the Greek sub-sample	Results for the Polish sub-sample
Fitted value from first-step equation ($\widehat{T_f}$)	-51.510** (23.020)	100.844** (45.124)	82.018 (81.385)	16.477 (51.469)
Farm total labour (L_f)	-0.003*** (0.001)	-0.002** (0.001)	-0.006 (0.005)	-0.005** (0.003)
Farm capital value (K_f)	-	0.00002*** (0.000)	0.001 (0.000)	-
Farm cattle herd size (K_f)	0.172*** (0.046)	-	-	0.656 (0.588)
Farm UAA (K_f)	0.058* (0.035)	-	0.418 (0.239)	2.311 (1.472)
Regional dummy (C_f)	-21.400*** (6.308)	-13.445 (14.911)	15.082 (29.408)	32.283 (23.713)
Field crop specialist dummy (C_f)	-	67.079*** (16.785)	-	-
Dairy specialist dummy (C_f)	4.219 (6.498)	-	-	-
Mixed farms specialist dummy (C_f)	-	-	-	-7.976 (15.781)
Intercept	71.183*** (14.897)	-21.923 (26.498)	-7.256 (31.294)	1.708 (11.813)
Pseudo R-square	0.391	0.618	0.015	0.248
Number of observations	107	44	104	73

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

5.5 Conclusions of the analysis on returns to skills

This part of the deliverable studies the effects of adopting ecological technologies on the returns to the skill level on farms.

Unique data from the LIFT large-scale farmer survey, is used from five countries – France, Greece, Hungary, Poland and England – that covers ecological farming practices and different economic variables. The methodological approach is in two steps, first to estimate the probability of adopting ecological technologies given the human capital of farms in the sub-samples of each country. The second step estimates how this skill conditional adoption probability affects the returns to labour.

Results in Hungary and Greece show no significant relationship between the probability of adopting an ecological technology through on farm experience and education – indicating that other factors might be more significant in the technology adoption, and thereby in the subsequent step they do not affect the returns to skill or that the model does not apply to the types of farms in these countries. The impact on returns to skills is markedly different between France and England. It appears that in France agricultural education has been predominantly conventional in nature, especially in the time when the survey respondents would have been attending colleges, and so it is perhaps more likely that these farmers would adopt conventional technologies and earn a higher return given their specialised education. Another possible reason for the difference between England and France is in the measure for returns to skills – data availability limited to use turnover for the French sub-sample while the English measure includes revenue from sales and subsidies. Therefore, the analysis on France captures the returns of skills from production activities whereas the results for England may reflect a higher skill level needed to obtain subsidies, e.g. from AES.

6 Conclusions from the deliverable

There is no theory that can guide researchers to *a priori* expectations about the effect of different farming practices on labour demand in quantitative terms and qualitative ones (skills). It is difficult to distil the differences between ecological farming approaches and more conventional farming practices in respect to labour, since the comparisons in previous studies have been carried out over different types of farming, farm sizes, and geographical regions.

Concerning farm labour, all five EU MSs analysed in this deliverable (France, England or the UK, Greece, Hungary, Poland) have had the same recent trends – a decrease in total labour used and substitution of permanent hired for family labour. The only major difference between the countries has been the rate of change. The dynamics has been more pronounced in the two EU NMSs – Hungary and Poland due to their market reforms post-1990s and the accession to the EU in 2004. Due to the economic crisis and austerity policies, Greece is an outlier in certain aspects of the labour market (e.g. compensation of employees).

By and large, apart from Hungary, there is a shortage of skills of current workers in comparison to what the employers are looking for. This might act as a barrier to implement new farming practices linked to ecological farming which require a new and often wider skill set.

In addition to the CAP, countries have had their own schemes either concerning social security and tax system for farming, enforcement of minimum wage or implementation of measures for stimulation of rural jobs in sparsely populated regions.

Concerning the intensity of labour use, the study results using FADN data in 2004-2015 show a similar pattern in all the countries: low external inputs and capital intensity, characterising farms implementing ecological approaches to farming, increases the intensity of labour use as a share of output (possibly through job creation) as these farms increase their use of external inputs and capital (this is a net mean effect of ecological approaches to farming as in some farms the labour intensity may have decreased). However, there is a tipping point when inputs and capital become substitutes for labour, and this may have an effect on the level of employment for hired labour and perhaps act as a disincentive to extensive farming for the farming family, potentially leading to job destruction. The pattern is identical amongst countries but the tipping point is country-specific. This analysis suggests a possible mechanism whereby the reduced output of these farms incorporating ecological approaches is compensated by the lower cost of input, thus going some way to the restoration or improvement of profit.

Bearing in mind that AES adoption is also taken as a proxy for farms adopting ecological approaches, these results suggest that farms which implement ecological farming practices may use more labour. Therefore, policies which support the adoption of ecological agriculture may have as a by-product increased (maintained) farm employment, and consequently, rural employment. This result, however, might only hold in short- to mid-term since technological change with wider introduction of precision agriculture, AI, robots may bring simultaneously a decrease in farm labour use and wider adoption of ecological farming practices.

In all five EU MSs the AEP increase labour use. This is an interesting result, bearing in mind that, concerning agri-environmental policy, the EU CAP includes a greater flexibility allowing MSs to design and implement their own programmes. This result implies that non-product output, produced by farmers participating in AES, is labour intensive.

The increased complexity of output, proxied by the number of enterprises (activities) on a farm, which is expected to be present in the farms using ecological farming practices, also results in higher labour intensity.

The policy implications of these results mean that cost minimising farmers might be reluctant to adopt ecological farming practices while trying to minimise labour costs. This implies that policy incentives might be necessary to stimulate the adoption of more ecological practices such as agroecology, since the latter has potential to provide important public goods and ecosystem services (PG and ES).

As a technological change towards ecological practices alters output and requires a higher intensity of labour use, it is hired labour that can more flexibly adjust the working hours up or down to the necessary labour content of output due to more or less individuals hired. As farming practices change, family labour may not be able to alter enough to compensate for a change in the labour content of output, because the number of individuals supplying labour is relatively fixed. Exogenously determined family members can only change working hours, and only occasionally may family labour switch from unemployment or other employment to working on farm. Our results indicate that ecological approaches to farming will mainly increase the use of hired labour, strengthening the existing trend of substitution of hired to family labour.

In all the countries analysed there are some regulations concerning hiring and firing of farm workers, which create transaction costs for the farmer. Government policies, which concerning labour market in agriculture have mainly focused on minimum wage and social insurance, need to be re-orientated towards a decrease of transaction costs allowing more flexible adjustments of hired labour in view of wider adoption of ecological farming practices. Further research should focus on a comparative study of best practice in the EU in this area to provide policy insights on how to build more flexibility in the market for hired farm labour.

The LIFT large-scale farmer survey implemented in case study regions of five EU MSs collected specific data for the year 2018. Results on this data shows that the levels of agricultural education of family members are far lower in Greece, Hungary and Poland compared to France and England. The nature of this education is also important, where it should enable students to develop a broad range of knowledge and abilities to tackle the variety of problems that farms encounter and maximise their economic return, whilst providing PG and ES as well as improving the quality of life of farmers.

The data sources did not allow for a systematic analysis of gender effects through adoption of ecological farming approaches, but some insights were taken from the literature review and Delphi exercise. Gender becomes more and more important from the point of view of employment, division of labour within the farm households and pay. However, the studies are on developing countries where customary traditions and norms are much stronger. This literature review shows that the impacts of introducing ecological practices in agriculture in developing countries does not have a clear-cut gendered effect on labour. The effect depends on on-farm labour division and on intra-household time allocation.

7 Deviations and delays

None

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9 Appendices

Appendix 1: Effects on total labour

Figure 2: Crop protection effects on total labour – all countries

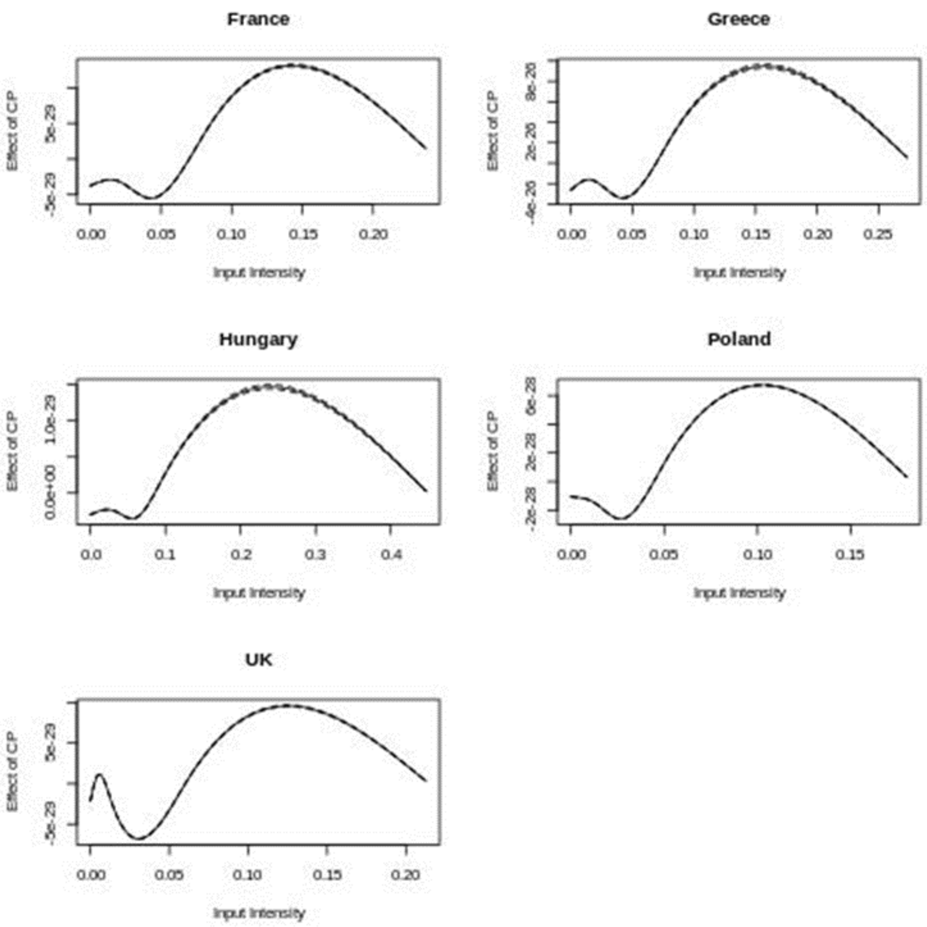


Figure 3: Fertiliser effects on total labour - all countries

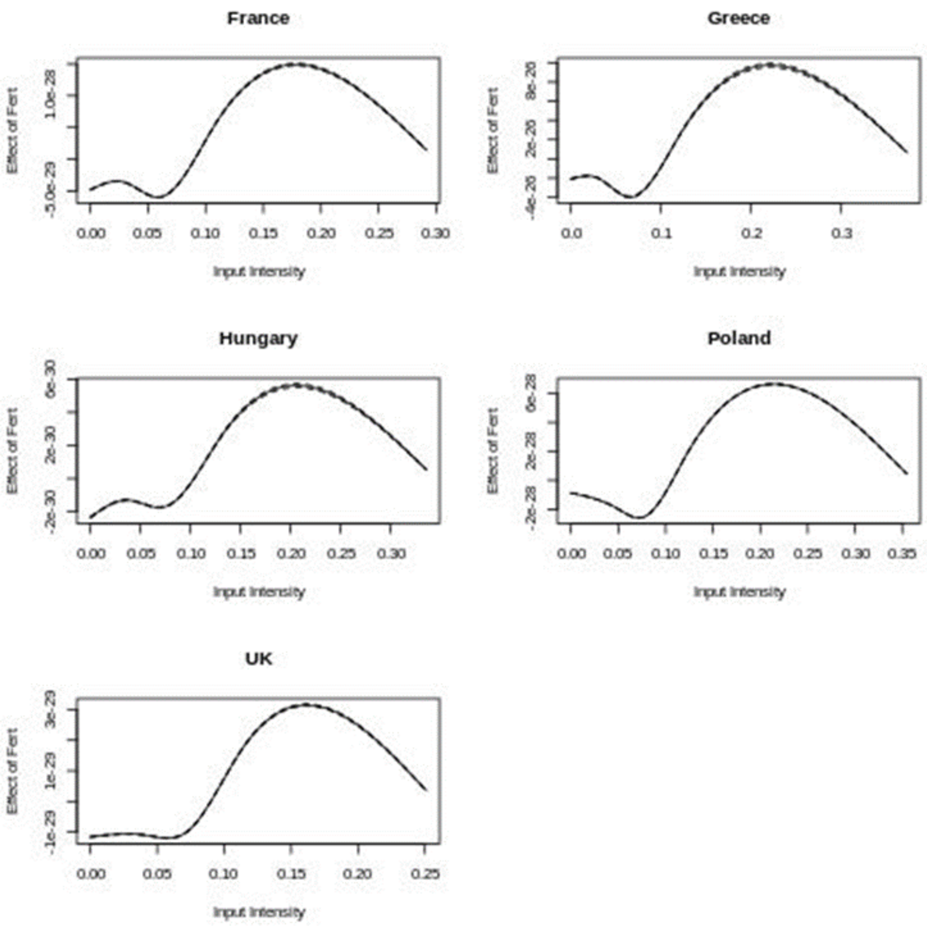


Figure 4: Fuel effects on total labour – all countries

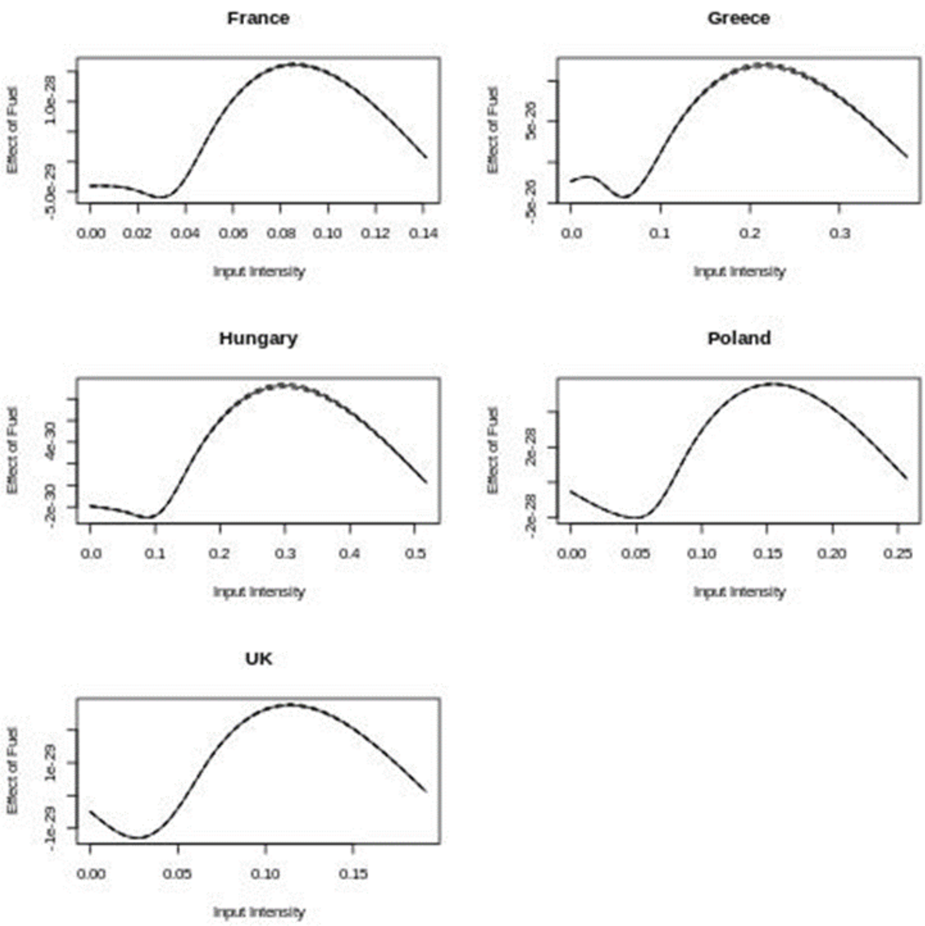


Figure 5: Capital effects on total labour – all countries

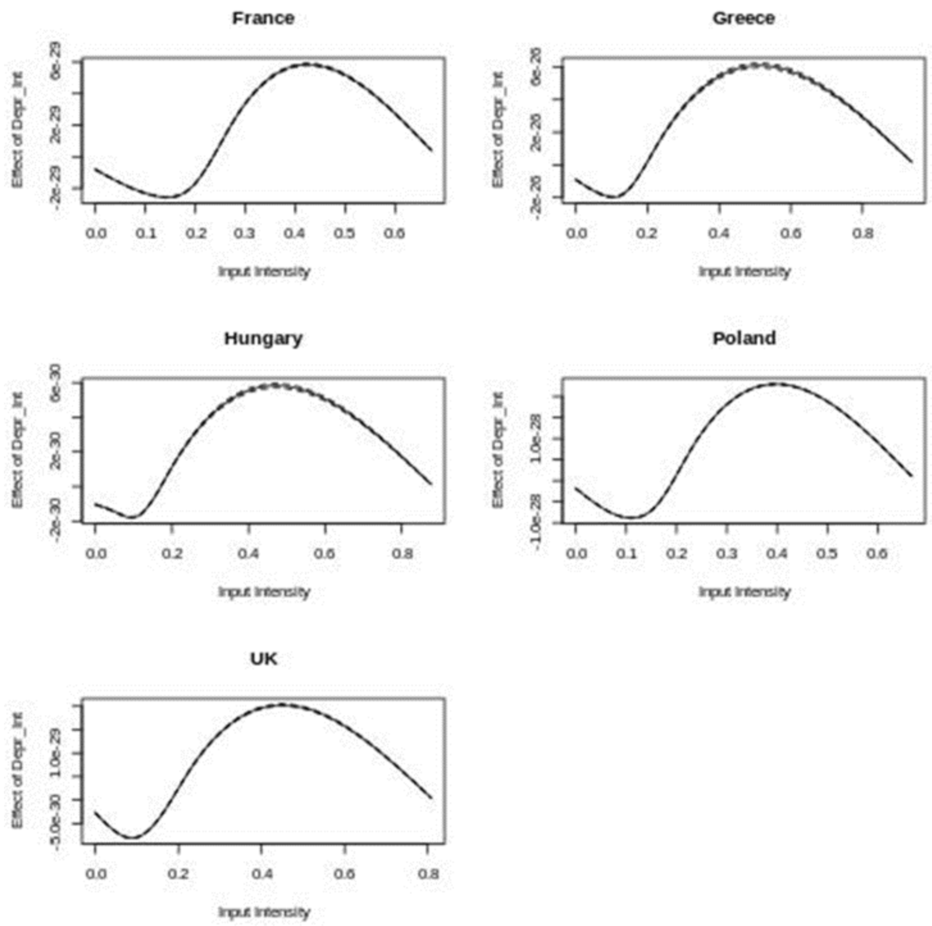


Figure 6: AEP effects on total labour – all countries

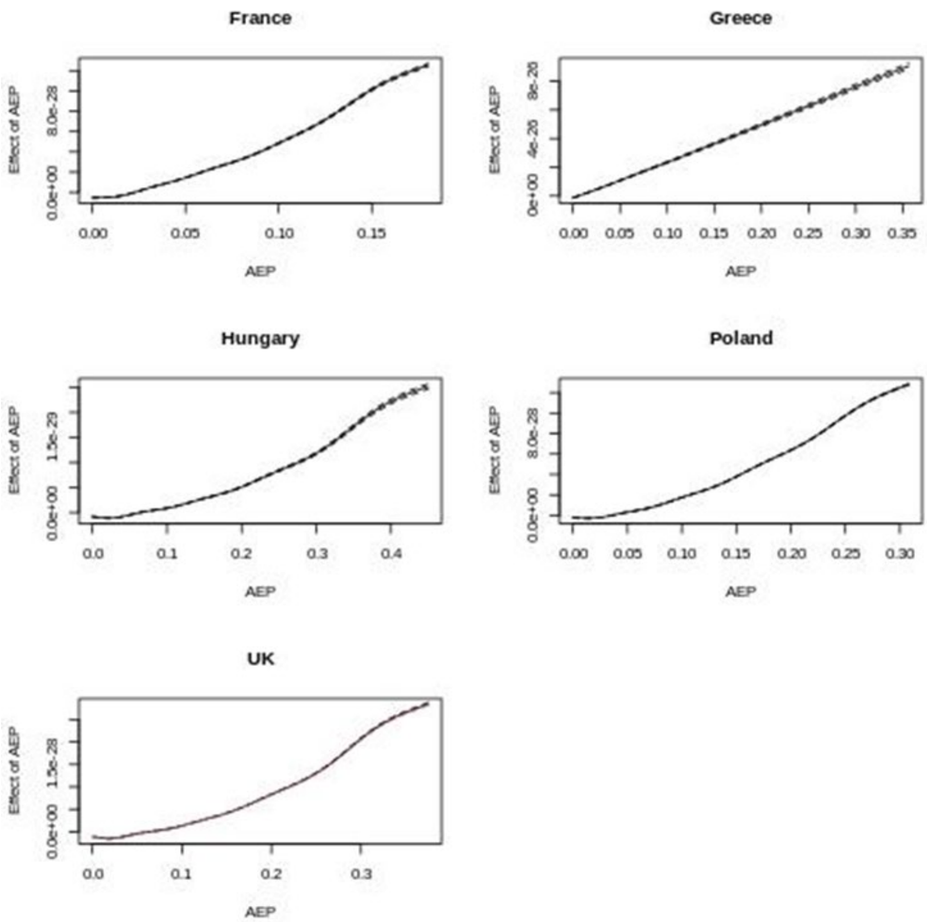
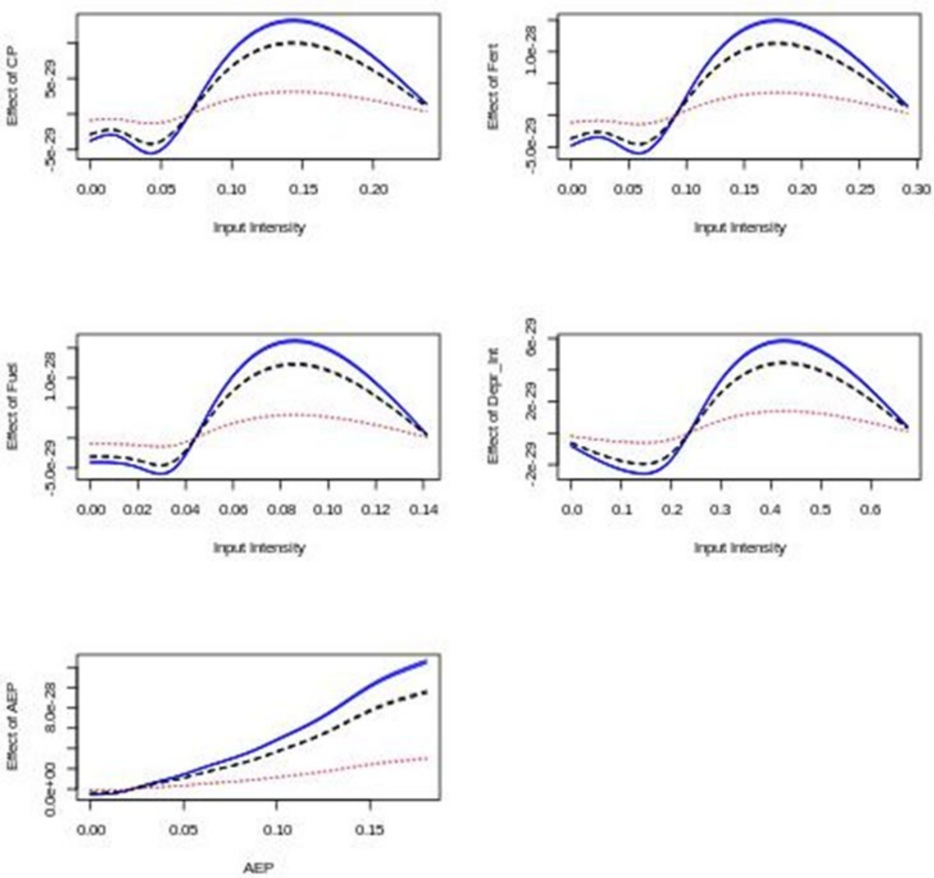
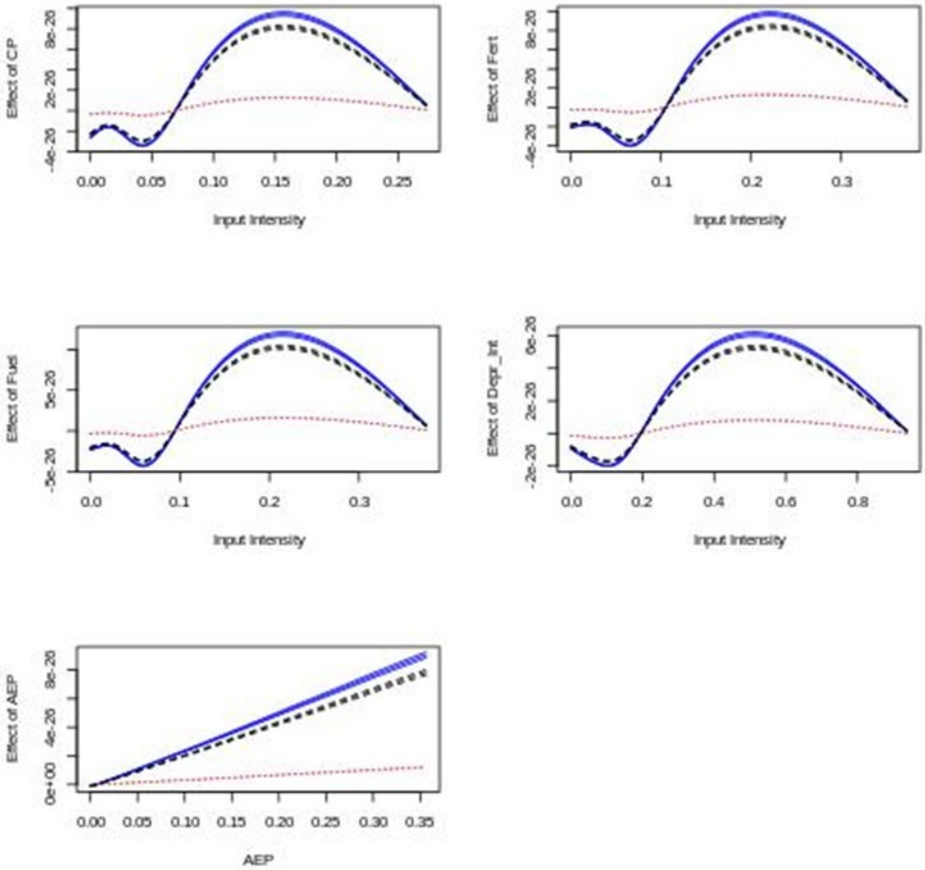


Figure 7: France (effects on total, family and hired labour)



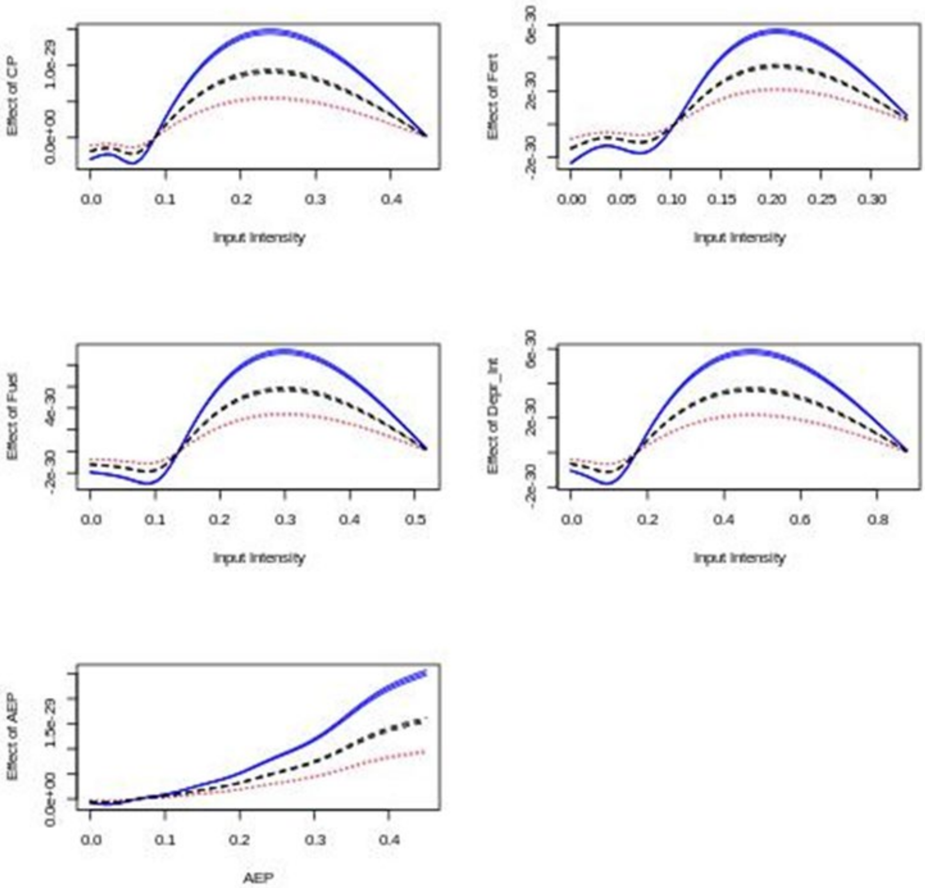
Note: In the figures the blue, solid line indicates the effect on total labour intensity, the black, dashed line on family and the red, dotted line on hired.

Figure 8: Greece (effects on total, family and hired labour)



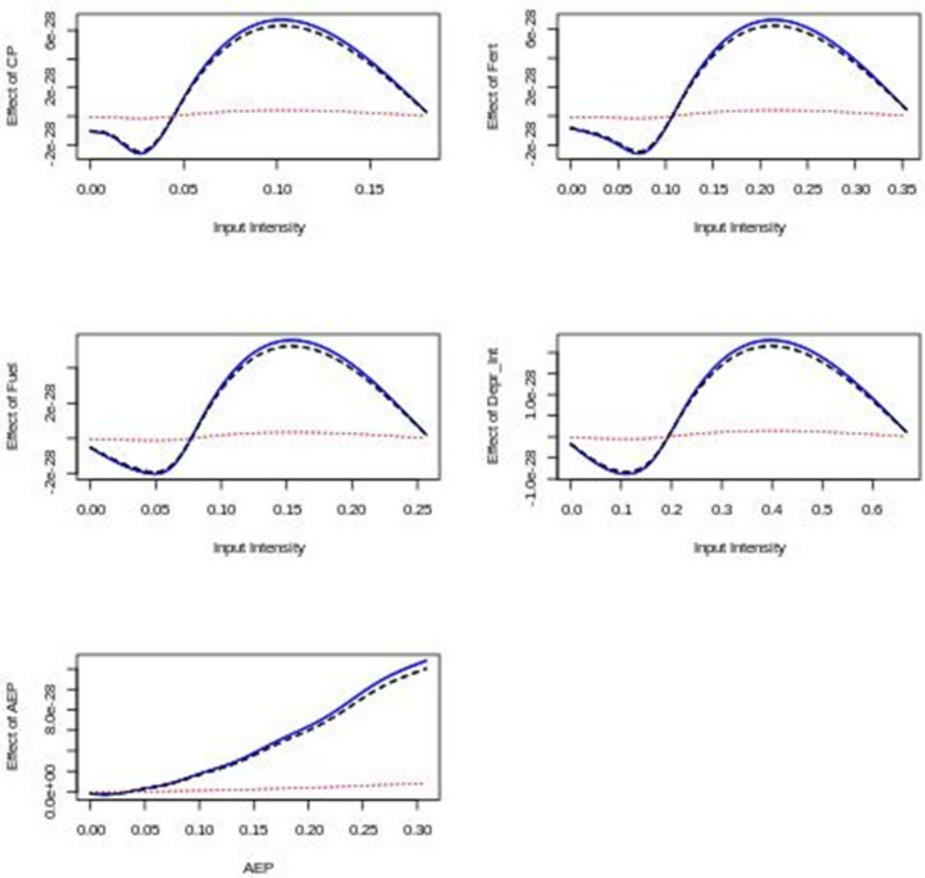
Note: In the figures the blue, solid line indicates the effect on total labour intensity, the black, dashed line on family and the red, dotted line on hired.

Figure 9: Hungary (effects on total, family and hired labour)



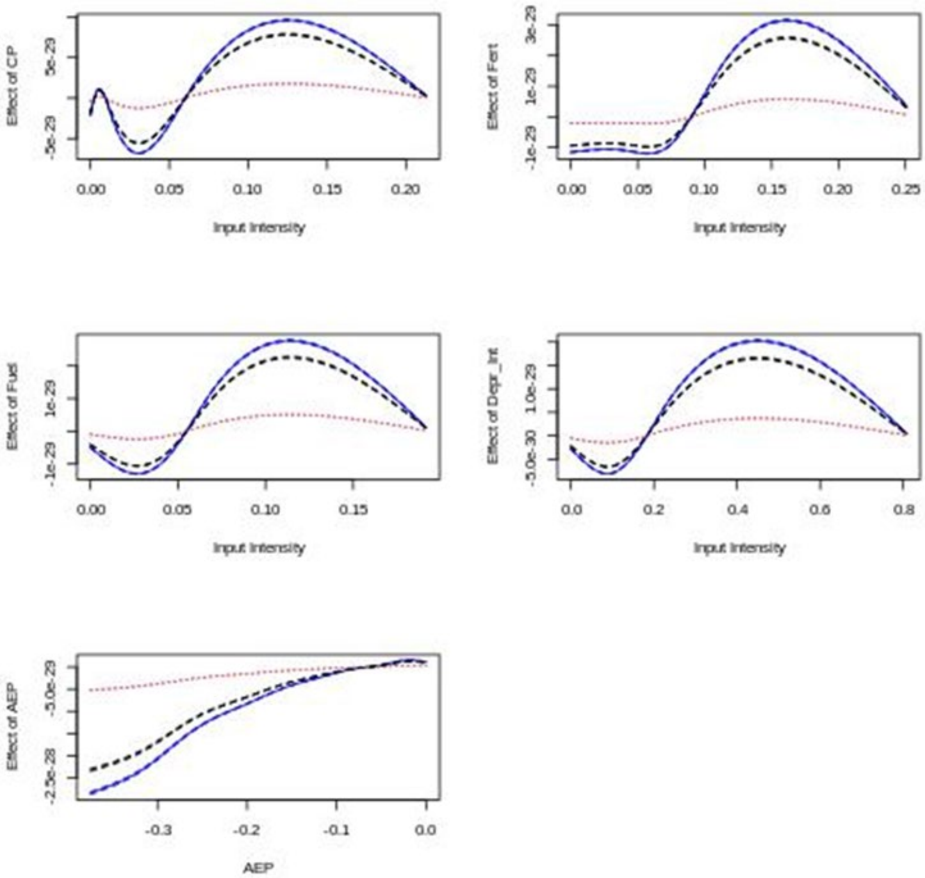
Note: In the figures the blue, solid line indicates the effect on total labour intensity, the black, dashed line on family and the red, dotted line on hired

Figure 10: Poland (effects on total, family and hired labour)



Note: In the figures the blue, solid line indicates the effect on total labour intensity, the black, dashed line on family and the red, dotted line on hired

Figure 11: UK (effects on total, family and hired labour)



Note: In the figures the blue, solid line indicates the effect on total labour intensity, the black, dashed line on family and the red, dotted line on hired

Appendix 2: Statistical analysis for Hungary

Table 12: Pairwise mean equality tests of family labour amount on ecological farm types

Conservation tillage = 1, 0 if not	**No. observations**	**Mean of family labour (hours)**
0	80	2,330
1	40	3,698
Test of equality of means: p-values for H_0: difference is not significant		
H_1: difference is <0	H_1: difference is not 0	H_1: difference is >0
0.000	0.000	0.999

Table 13: Pairwise mean equality tests of hired labour amount on ecological farm types

Conservation tillage = 1, 0 if not	**No. observations**	**Mean of hired labour (hours)**
0	80	23,086
1	40	22,825
Test of equality of means: p-values for H_0: difference is not significant		
H_1: difference is <0	H_1: difference is not 0	H_1: difference is >0
0.516	0.9797	0.4898

Table 14: Pairwise mean equality tests of total labour amount on ecological farm types

Conservation tillage = 1, 0 if not	**No. observations**	**Mean of total labour (hours)**
0	80	25,416
1	40	26,523
Test of equality of means: p-values for H_0: difference is not significant		
H_1: difference is <0	H_1: difference is not 0	H_1: difference is >0
0.4573	0.914	0.542

Table 15: Pairwise mean equality tests of average family farm experience on ecological farm types

Conservation tillage = 1, 0 if not	No. observations	Mean of average family farm experience (years)
0	78	26
1	40	26
Test of equality of means: p-values for H_0: difference is not significant		
H_1: difference is <0	H_1: difference is not 0	H_1: difference is >0
0.495	0.990	0.504

Table 16: Pairwise mean equality tests of average family age on ecological farm types

Conservation tillage = 1, 0 if not	No. observations	Mean of average family age (years)
0	78	52
1	39	52
Test of equality of means: p-values for H_0: difference is not significant		
H_1: difference is <0	H_1: difference is not 0	H_1: difference is >0
0.440	0.880	0.559

Table 17: Pairwise mean equality tests of total wage on ecological farm types

Conservation tillage = 1, 0 if not	No. observations	Mean of total wage (HUF)
0	58	353,204
1	37	289,099
Test of equality of means: p-values for H_0: difference is not significant		
H_1: difference is <0	H_1: difference is not 0	H_1: difference is >0
0.951	0.096	0.048