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The use of Farm Business Survey data to compare the environmental performance of organic and conventional farms

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ABSTRACT

This paper considers two main questions: Is it possible to use Farm Business Survey (FBS) data to derive well-established environmental indicators and can these FBS derived indicators also provide a reasonable comparison of the environmental performance of organic and conventional farms? The results suggest that the indicators can be obtained from FBS data and that the majority of the indicators provided meaningful results, despite some data limitations within the FBS dataset. The comparison of organic with conventional FBS data in the UK suggests that organic farms have lower fertiliser and crop protection costs (as would be expected) but that differences in feed costs, stocking density and cropping diversity were dependent upon farm type. This research confirms that FBS data can be used to derive indirect environmental indicators which are able to identify significant differences between farm types and management systems. These indicators are also likely to be applicable at EU level through their use within the Farm Accountancy Data Network (FADN), which collates farm economic data across the EU. This is of interest to researches and policy-makers who could use FADN data to track some aspects of environmental performance across many countries and track changes over time. These results may also be useful to farm consultants and managers who could potentially use a similar approach in using individual farm financial information to benchmark some aspects of farm environmental performance.

KEYWORDS: Farm business survey; environmental indicators; organic

1. Introduction

The environmental impact of agriculture is an area of increasing concern to the general public, to policy-makers (European Commission, 2011) and other stakeholders, including farmers themselves. As part of a move to more environmentally friendly agriculture, 18% of the EU-27's utilisable agricultural area is managed under agri-environmental schemes (Westbury *et al.* (2011) and references therein) and it is possible that this may increase further in the future. In a further strengthening of agri-environment policy, current proposals for common agricultural policy (CAP) reform include a 'greening payment' to encourage environmentally friendly farming practices (European Comission: Agriculture and Rural Development, 2011).

To justify continued financial support for agriculture in the EU it is necessary to have some means of tracking changes in agricultural practice which may impact on the environment. For instance being able to assess whether implementation of greenhouse gas action plans appears to be having an impact on emissions will become increasingly important as the UK fulfils its obligations under the Climate Change Act (2008). With agri-environmental schemes operational in all countries throughout the EU, measuring the impact of such schemes and providing evidence that they do provide environmental benefits is becoming increasingly necessary to justify this public expenditure. Consumers also express an interest in the environmental benefits of the farming systems used to produce their food (Hughner *et al.*, 2007; Mondelaers *et al.*, 2009b; Zander and Hamm, 2010) , suggesting that it will become increasingly important for producers to be able to assess the environmental impacts of their farm management and communicate these to their customers.

One means of assessing the environmental benefits of farming is to carry out assessments on-farm (Hani *et al.*, 2003; Meul *et al.*, 2008). However, on-farm assessment can be time consuming for the advisor/assessor and the farmer. Also, if the aim of assessment is to obtain a national picture (for example assessing a particular agricultural policy or agri-environment scheme) then a (possibly prohibitively) large number of assessments in various parts of the country, covering various farm types would be required.

An alternative approach would be to make use of existing surveys which could be analysed to provide indicators of environmental performance. The potential disadvantage of indicators which make use of existing surveys in the manner described above is that they do not directly measure the environmental aspect which

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they are assessing but rather give information about management practices or other aspects that may influence it (Bookstaller *et al.*, 2008; Makowski *et al.*, 2009). It is necessary to assess the validity of such 'indirect' or 'proxy' indicators as they are potentially less accurate than direct measurement. However, the advantage of such indicators is their lower cost (Bookstaller *et al.*, 2008; Makowski *et al.*, 2009) and the ability to use surveys which have been carried out regularly over a long period of time and so to track changes in practices which may impact on the environment. This advantage means that it is worth investigating the use of indirect indicators further and this has been explored in a number of European research projects e.g. IRENA (EEA, 2005), SEAMLESS (Van Ittersum *et al.*, 2008), BioBio (Dennis, 2009).

Some projects, e.g. IRENA and SEAMLESS, have tried to combine environmental and financial databases to undertake integrated assessments but due to their complexity have often been unable to provide results across the EU or have not been updated regularly due to high costs. However, it may be possible to achieve at least a basic environmental performance indication from annual data collections such as economic or financial surveys e.g. the EU FADN (farm accountancy data network). Thus, it appears necessary to explore whether it is possible to obtain such environmental indicators from financial information in existing surveys.

In England and Wales the FADN data is collected through The Farm Business Survey (FBS). It is a survey of farm income and expenditure which is carried out in England and Wales on an annual basis on a representative sample of farms (based on proportions of different farm sizes and types within the sample as compared to the overall population of UK farms based on Farm Structure Survey data). Therefore it is a potential candidate for use in providing indirect environmental indicators. Similar surveys are also carried out in Scotland and in Northern Ireland which records more detail on fertilisers and physical quantities of feeds.

As part of the FADN, indicators that are developed utilising FBS data may also be transferrable for use in other countries. However, the survey focuses on financial rather than physical or environmental data. Thus some indicators may require additional calculation to convert from financial to physical values. Others may not give as much detail as would be ideal from an environmental assessment perspective.

Westbury *et al.* (2011) investigated the use of FBS data to carry out an agri-environmental footprint index (AFI) assessment to measure the environmental impact of arable, lowland livestock and upland livestock farming in England and to assess whether there were differences in AFI due to participation in agri-environmental schemes. The variables they used included fertiliser units (tonnes, derived from cost) per ha utilisable agricultural area (UAA), crop protection costs per ha UAA, % of UAA that was irrigated, electricity costs and machinery, heating and vehicle fuels and oil per ha UAA, Shannon indices of both crop diversity and land-use diversity, the percentage of farm land that was woodland or uncropped land, average number of livestock units per ha UAA, and percentage of UAA that was classified as rough grazing. Where physical units rather than costs were required they were obtained using standard costs (i.e. costs for that specific product pertaining at that time).

Similarly, Corson *et al.* (2010) used FADN data but focussed on the use of such data to estimate emission inventories of French farms. They estimated fertiliser nitrogen, phosphorus and potassium (N, P, K) inputs, pesticide inputs and the N, P, K imported in animal feed and the amount of N, P, K output based on quantities of agricultural products sold. Physical amounts were obtained from cost data using standard costs and information on the concentration of N, P, and K in commercially available fertilisers and animal feedstuffs.

Environmental indicators have also been developed as part of EU-funded research projects, (as mentioned above). The EU-funded BioBio project ('Indicators for Biodiversity in Organic and Low Input Farming Systems') suggested a range of indicators under the main headings of genetic, species, and habitat diversity and included a section on farm management indicators that can be derived from existing data sets (Dennis, 2009). Also, the 'Indicator Reporting on the Integration of Environmental Concerns into Agricultural Policy' (IRENA) project aimed to develop a set of indicators for monitoring environmental integration into the CAP (EEA, 2005). Those indicators which they deemed 'useful' included; area under nature protection or organic farming, cropping or livestock patterns, level of intensification, population of farmland birds, emissions of methane, nitrous oxide or ammonia, land use change. However, it is worth noting that not all of these indicators are easily assessed using the financial data available from FADN/FBS.

In this paper the potential of FBS data to provide environmental indicators is investigated by considering a comparison of conventional and organic farming systems with the main aim of assessing whether is it possible to derive some of the well-established environmental indicators developed in the above mentioned projects from a set of Farm Business Survey (FBS) data.

The study focused on well established indicators selected from a range of sources including those referred to above because they have been found by other authors to be useful in assessing the environmental impact of farming (see Table 1) and because they could be derived from farm income/business data. Similar indicators have been suggested by many other authors (Cooper *et al.*, 2009; Halberg *et al.*, 2005a; Halberg *et al.*, 2005b), although without a view to deriving them from accounts/economic data sets.

As the indicators were used outside the context in which they were originally developed, it was necessary to verify that they give reasonable results in this new context. This was done by using them in a comparison of organic and conventional farms. As discussed previously, successful identification of indirect indicators of environmental performance which could be derived from financial data would be useful to both researchers and policy-makers. The long term records stored within the FBS dataset allow continuous, long-term coverage of the changing situation across a range of farm types (and potentially countries using FADN data). Thus such indicators could therefore be used to evaluate the impact of various policy decisions. The approach could also be of potential interest for consultants and farm managers who could use financial

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Table 1: The indicators used in this study and the previous research which supports the use of these indicators.

Indicators	Eurostat (2011)	Biobio (Dennis, 2009)	IRENA (EEA, 2005)	Westbury *et al.* (2011)	Gomez-Limon and Sanchez-Fernandez (2010)
Fertiliser use	X	X	X	X	X
Pesticide use	X	X	X	X	X
Purchased feed use		X	X		
Intensification/ Extensification	X		X		
Agri-env schemes		X	X		X
Crop/land-use diversity	X	X	X	X	X
Average LUs per ha forage		X		X	

data that a farm must keep for taxation purposes to derive some level of environmental information about that farm.

The paper aims to answer two main questions. Firstly it aims to assess whether such environmental indicators can be successfully derived from the mainly financial data collected in the Farm Business Survey and secondly it aims to use these indicators to compare organic and conventional farms as a means of verifying the effectiveness of the indicators. Section 2 discusses the indicators used and how they have been derived from FBS data. Section 3 presents the results from using these indicators, demonstrating their use in comparing organic and conventional systems across farm types. Section 4 discusses the results and the potential for the use of these types of indicators in the future.

2. Methods

The use of FBS data to provide environmental indicators was investigated using FBS data from 2008–09 (Department for Environment Food and Rural Affairs and National Assembly for Wales, 2008–2009) and 2009–10 (Department for Environment Food and Rural Affairs and National Assembly for Wales, 2009–2010). The data were unweighted as the weightings provided with FBS data do not take into consideration whether or not a farm is organic and so may not result in a representative sample for organic farms (Hansen *et al.*, 2009). The FBS database has two main sections: the 'Calcdata' section contains the variables which Defra (UK Department for Environment Food and Rural Affairs) considers will be most useful to researchers and policy makers. These include variables such as LFA status, region, livestock units for various livestock types, costs of various inputs, and areas of various crops. Some of these are taken directly from the farm return data collected, others are calculated by Defra from the farm return data. The second section of the database is the 'FASdata' section which contains all of the farm return data collected. The variables used to calculate the indicators (shown in italics below) were taken from the 'Calcdata' section of the FBS database.

For several indicators two denominators are shown. The use of UAA as a denominator can be seen as giving a bias towards extensive farming as extensive systems are likely to have a higher denominator, giving a lower total value for the indicator and, in many cases, implying a lower environmental impact. However extensive farms may also potentially have lower yields. Therefore, the financial output was also used as a denominator in some cases as a proxy for production levels. The output value excluding subsidies was used in this study as, since decoupling, subsidies in general do not tend to vary with physical output and so this was deemed to be the best proxy for production levels.

The indicators and the FBS variables used to calculate them (text in italics) are listed in Table 2 below.

The Shannon crop diversity index sums over all the crops considered. For example, if a farm has 20ha of crops, consisting of 15ha wheat and 5 ha oats the Shannon diversity index would be: $H = -(15/20)\ln(15/20) - (5/20)\ln(5/20)$. The higher the result, the greater the diversity (one single crop will give $H=0$). The 'total area considered' was taken as the denominator in the area fractions due to the fact that the FBS crop areas can include main crops and multiple cropping (i.e. where more than one crop is planted in a year they will count both crops) whereas UAA and other total areas calculated in the 'Calcdata' section of the FBS database only use the main crop areas (i.e. they correctly measure the total area of the farm but therefore if a field is cropped twice in one year do not take that into consideration) and so using these as denominators could result in a negative Shannon index. Farms with no land in any of these categories were excluded from the sample.

The data were split into the 'robust farm types' (cereals, general cropping, horticulture, pigs, poultry, dairy, LFA [less favoured area] grazing livestock, lowland grazing livestock, mixed and 'other' farms). Where 'all' farm results are quoted, these are not weighted based on the sample sizes of the individual farm types and so can be skewed by one farm type with particularly high or low values for the indicator e.g. the horticulture farm results skew the 'all' farms results upwards for the intensity indicator. The 'robust farm types' are a Defra classification of farm types which aggregates some of the EC types (which are very specialised) to provide 10 types of farm as described above. Farms are classified into one of these types based on the contribution of different enterprises towards their overall financial situation (i.e. based on output per production unit). Following the disclosure requirements for Defra, samples of five farms or fewer cannot be published.

As farm types are being directly compared within a year it would be possible to use costs as proxies for physical amounts without taking into consideration price changes, as would be necessary if performance across several years was analysed. The limitations of this approach are discussed in the conclusions.

The results of this comparison are discussed later in this paper with regards to the question of whether FBS data can be useful in providing environmental

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Table 2: Indicators used and their calculation using FBS calcdata variables.

Indicator	Calculation
Cost of fertiliser per ha utilisable agricultural area (UAA) and per output	*agriculture.fertiliser.costs/UAA* and *agriculture.fertiliser.costs/ output.from.agriculture.excl.subsidies*
Cost of pesticide per ha UAA and per output	*agriculture.crop.protection.costs/UAA* and *agriculture.crop.protection.costs/ output.from.agriculture.excl.subsidies*
Purchased feed per UAA and per livestock units (LU)	*(feedingstuffs.costs.purchased-fodder.costs)/UAA* or *LU*
An intensification indicator (EEA, 2005) consisting of the sum of fertiliser cost, pesticide cost and purchased concentrate cost divided by UAA	*(agriculture.fertiliser.costs+agriculture.crop.protection.costs+(feedingstuffs. costs.purchased-fodder.costs))/UAA*
Monetary receipts from agri-environmental schemes per ha UAA	*agri.environment.schemes.payments/UAA*
Average number of grazing livestock units (GLUs) per ha of forage area	*Grazing.LU/(forage.grazing.fallow.area-fallow.area)*
Shannon crop diversity index	*Shannon crop diversity index* $= H = -\sum p_i ln(p_i)$ Where each p_i is the area fraction of each individual crop (i.e. the area of the crop over the total cropping area). The area fractions are calculated as: *barley.area / total area considered*, *beans.area / total area considered*, *horticulture.area / total area considered*, *oilseed.rape.area / total area considered*, *peas.area / total area considered*, *potatoes.area / total area considered*, *permanent.grass.area / total area considered*, *sugar.beet.area / total area considered*, *wheat.area / total area considered*, where total area considered was calculated as: *Total area considered = barley.area + beans.area + horticulture.area + oilseed.rape.area + peas.area + potatoes.area + permanent.grass.area + sugar.beet.area + wheat.area.*

indicators. For all of the indicators, where the denominator is zero (giving a divide by zero error) the farm is excluded from the sample for that particular indicator.

For each indicator the mean and median are quoted. The means of ratios were calculated by taking the ratio for each individual farm and then averaging over all farms i.e. taking mean(A/B) rather than mean(A)/mean(B). This approach was taken as it is the calculation method which must be used in taking the medians and so it meant that the formulae were consistent across the main descriptive statistics used. Also, calculating the mean in this way gives each farm equal weighting. It will mean, however, that farms with larger values for the ratios will result in a larger overall mean than if mean(A)/mean(B) were used but this is balanced by also taking the median which is much less susceptible to outliers.

Two approaches were taken to assessing the significance of any apparent difference in performance on each of the indicators between organic and conventional farms of each farm type. A two-tailed t-test was used to compare organic and conventional farms (Levene's test was carried out first to evaluate whether or not the variances were equal and then the appropriate p-value was taken based on this). However, this commonly used test for comparing two samples of data assumes that the data has a Gaussian (also known as normal) distribution. In the case of FBS data split by farm type this assumption did not often hold true. As the organic and conventional data sometimes had different distributions, it was not possible to use transformations to regain a Gaussian distribution. The data were therefore also evaluated using a non-parametric test, the Mann-Whitney U test. This test compares medians (rather than means as in the t-test) and so is less likely to be influenced by outliers and does not assume a Gaussian distribution for the data.

The Mann-Whitney p-values quoted were based on the asymptotic significance as the exact significance test was too demanding of computing power and so could not be completed, a common issue in using this test. The Mann-Whitney U tests were also re-run using the alternative Monte Carlo significance test. This gave the same results for all of the variables except for purchased feed cost/livestock units for LFA grazing livestock farms, and grazing livestock units per forage area for LFA grazing livestock farms. In both cases a very slight difference in p-value led to a difference in significance level and in both cases the asymptotic significance gave the lower significance and so, to err on the side of caution, is the significance level quoted in the tables below. Where the results of both the t-test and the Mann Whitney U test agree there is a strong assurance that the result is accurate. Where they disagree the Mann-Whitney U test has been assumed to be the more accurate as its assumptions are better suited to this data set.

In all of the tables showing the statistical results *** represents significance at the 0.5% level, ** at the 1% level, * at the 5% level, N.S indicates that no statistical significance was found and n/a indicates that no comparison of organic and conventional was carried out either because the organic sample was unavailable or, in the case of 'all farms', because the farm-type specific tests are more meaningful. Both tests were run using SPSS Statistics (V18) (IBM, 2009).

In all of the comparisons there was good agreement between the 2008–09 and 2009–10 data and therefore only the results for 2009–10 data are presented in Section 3, however it will be highlighted in the discussion where there were differences between the two years. For most variables the mean values were considerably higher than the median value, due to outliers with very high values. Therefore the median

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value may be more indicative of typical values for each farm type.

3. Statistical results of the comparison

This section presents the statistical results, followed by a discussion of the implications of these with regards to verifying that these indicators are valid in the following section.

Fertiliser costs per UAA and per output

Considering individual farm types, it can be seen from Table 3 that horticultural farm expenditure was highest for fertiliser per UAA whereas poultry farms spent the least; costs were also low for pig farms and both types of grazing farms. Considering costs per financial output, poultry and pig farms again showed low costs but there were higher costs for cereals and general cropping farms. LFA grazing livestock farms had higher fertiliser costs per output than other livestock-related farm types (possibly due to lower financial income).

The statistical significance of the results is also investigated in Table 3. This shows the mean and median fertiliser costs per UAA and per financial output for conventional (marked CF) and organic (marked OF) farms and the results of the t-test and Mann-Whitney U test. It can be seen from these that there is good agreement that fertiliser cost differs significantly between organic and conventional farms for all farm types, as would be expected from the nature of organic farming (Mondelaers *et al.*, 2009a). Only for horticultural farms in 2009/10 (and in 2008/09 for the t-test only) does there appear to be a lower significance.

Crop protection costs per UAA and per output

Table 4 indicates that horticultural farms had the highest costs for crop protection per UAA and that pig, poultry and grazing livestock farms (LFA and lowland) had lower expenditure. It was also found that cereals and general cropping farms had the highest crop protection costs per financial output (Table 4) whilst poultry farms had the lowest.

Crop protection costs differed significantly across the farm types whether the denominator was UAA or financial output and that organic farms had significantly lower costs, which would be expected due to severe restrictions on crop protection usage on organic farms.

Purchased feed cost per UAA and per LU

This indicator included both purchased forage and purchased concentrates, and Table 5 indicates that the purchased feed costs were particularly high on poultry and pig holdings (both per UAA and per LU). However, it should be noted that for both of these there was limited or no organic data. Lowland grazing livestock farms in particular had lower purchased feed costs with LFA grazing livestock farms having slightly higher costs. Dairy holdings had higher purchased feed costs than grazing livestock farms but lower than pig and poultry holdings.

There was less of a significant difference between purchased feed costs for organic and conventional farms than there was for fertiliser or crop protection costs (Table 5). For dairy farms the purchased feed cost per livestock unit was slightly higher for organic than for conventional farms but this was generally not significant (or only significant at a low confidence level in 2008/09) and probably reflects the higher price of organic feed rather than greater use of purchased feed, and is discussed further later. For lowland grazing livestock there was a greater difference, with organic farms having significantly lower purchased feed costs. This was also reflected in LFA grazing livestock farms although with slightly lower significance. In general, the results for mixed farms indicated that median

Table 3: Statistical results for fertiliser cost /UAA (£/ha) indicator and fertiliser cost / output (£/£) indicators

		Fertiliser cost per UAA					Fertiliser cost per output (£)[i]				
Farm type		sample	mean	t-test	median	Mann-Whitney	sample	mean	t-test	median	Mann-Whitney
Cereals	CF	356	158	***	156	***	356	0.201	***	0.198	***
	OF	17	11		0		17	0.021		0.000	
General cropping	CF	197	175	***	158	***	197	0.141	***	0.132	***
	OF	12	19		9		12	0.015		0.003	
Horticulture	CF	200	5897	N.S	365	*	201	0.036	N.S	0.027	*
	OF	10	3246		21		10	0.024		0.005	
Pigs	CF	54	37	n/a	0	n/a	62	0.01	n/a	0.000	n/a
Poultry	CF	52	11	n/a	0	n/a	67	0.002	n/a	0.000	n/a
Dairy	CF	397	145	***	136	***	397	0.06	***	0.054	***
	OF	51	8		0		51	0.004		0.000	
LFA grazing livestock	CF	252	47	***	39	***	525	0.083	***	0.076	***
	OF	41	7		0.6		41	0.02		0.001	
Lowland grazing livestock	CF	253	53	***	32	***	253	0.06	***	0.046	***
	OF	32	6		0		32	0.008		0.000	
Mixed	CF	185	96	***	93	***	185	0.097	***	0.076	***
	OF	23	13		0		23	0.016		0.000	
All	CF	2253	616	n/a	92	n/a	2275	0.092	n/a	0.071	n/a
	OF	190	179		0		190	0.013		0.000	

[i]In late September 2012, £1 was approximately equivalent to €1.25 and US$1.62.

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Table 4: Statistical results for crop protection cost/UAA (£/ha) indicator and for the crop protection cost/output (£/£) indicators

		Crop protection cost / UAA					Crop protection cost / output				
Farm type		sample	mean	t-test	median	Mann-Whitney	sample	mean	t-test	median	Mann-Whitney
Cereals	CF	356	107	***	105	***	356	0.135	***	0.128	***
	OF	17	2		0		17	0.004		0.000	
General cropping	CF	197	138	***	120	***	197	0.105	***	0.102	***
	OF	12	13		9		12	0.007		0.006	
Horticulture	CF	200	1062	N.S	430	***	201	0.028	***	0.013	***
	OF	10	491		0		10	0.005		0.000	
Pigs	CF	54	38	n/a	0	n/a	62	0.009	n/a	0.000	n/a
Poultry	CF	52	11	n/a	0	n/a	67	0.002	n/a	0.000	n/a
Dairy	CF	397	18	***	11	***	397	0.007	***	0.004	***
	OF	51	0		0		51	0		0.000	
LFA grazing livestock	CF	525	2	***	1	***	525	0.004	***	0.002	***
	OF	41	0		0		41	0		0.000	
Lowland grazing livestock	CF	253	9	N.S	3	***	253	0.008	***	0.004	***
	OF	32	1		0		32	0.002		0.000	
Mixed	CF	185	54	***	42	***	185	0.046	***	0.044	***
	OF	23	6		0		23	0.004		0.000	
All	CF	2253	133	n/a	15	n/a	2274	0.04	n/a	0.008	n/a
	OF	190	28		0		190	0.002		0.000	

organic feed costs were lower, although the results were not significantly different.

Purchased concentrate cost per UAA and per LU

Considering individual robust farm types (Table 6), it can be seen that the highest costs per livestock unit occurred for pig and poultry farms followed by dairy farms. LFA and lowland grazing livestock farms had much lower costs for concentrate feed.

As for purchased feed cost, there is less of a significant difference between organic and conventional farms with regards to purchased concentrate costs than for fertiliser or crop protection costs. For dairy farms the purchased concentrate cost per livestock unit was slightly higher for organic than for conventional farms but this was generally not significant (or only significant at a low confidence level in 2008/09) and again probably reflects higher organic feed prices rather than greater use of purchased concentrates. For lowland grazing livestock there was a stronger significant difference, with organic farms having lower purchased concentrate costs. This was similarly reflected in LFA grazing livestock farms though with lower significance.

The minima were negative for a small number of farms (10 farms) i.e. *fodder.costs* exceeded *feedingstuff.costs.purchased*, suggesting that the *fodder.costs* variable may include some home-grown forage cost and so this indicator approximates the cost of purchased concentrates but may underestimate it. Extracting data directly from the FBS fieldbook data may allow the use of exact purchased concentrate value, but was not undertaken within the confines of this project.

Intensification indicator

The intensification indicator is based on IRENA Indicator 15 (EEA, 2005), and consists of the sum of

Table 5: Statistical results for purchased feed cost /UAA (£/ha) indicator and for the purchased feed cost/LU (£/LU) indicators.

		purchased feed cost /UAA					purchased feed cost/LU				
Farm type		sample	Mean	t-test	Median	Mann-Whitney	sample	mean	t-test	median	Mann-Whitney
Pigs	CF	54	26556	n/a	3885	n/a	62	529	n/a	595	n/a
Poultry	CF	52	164764	n/a	8720	n/a	67	1228	n/a	592	n/a
Dairy	CF	397	703	*	633	**	397	341	N.S	340	N.S
	OF	51	549		511		51	380		383	
LFA grazing livestock	CF	525	123	***	91	***	525	121	**	109	***
	OF	41	68		44		41	87		59	
Lowland grazing livestock	CF	253	188	N.S	90	***	253	100	***	71	***
	OF	32	30		11		32	34		15	
Mixed	CF	185	294	N.S	294	N.S	185	204	N.S	85	N.S
	OF	23	483		44		23	175		54	
All (incl cereals, horticulture, gen cropping)	CF	2253	4645	n/a	70	n/a	1833	231	n/a	123	n/a
	OF	190	380		47		177	191		73	

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Table 6: Statistical results for purchased concentrate cost /UAA (£/ha) indicator and the purchased concentrate cost/LU (£/LU) indicator

		purchased concentrate cost /UAA					purchased concentrate cost/LU				
Farm type		sample	mean	t-test	median	Mann-Whitney	sample	mean	t-test	median	Mann-Whitney
Pigs	CF	54	26552	n/a	3885	n/a	62	528	n/a	595	n/a
Poultry	CF	52	164764	n/a	8720	n/a	67	1228	n/a	592	n/a
Dairy	CF	397	666	*	588	**	397	323	N.S	313	N.S
	OF	51	521		485		51	363		365	
LFA grazing livestock	CF	525	104	**	77	***	525	100	*	87	***
	OF	41	61		41		41	76		52	
Lowland grazing livestock	CF	253	173	N.S	82	***	253	92	***	66	***
	OF	32	25		10		32	28		12	
Mixed	CF	185	286	N.S	71	N.S	185	196	N.S	79	N.S
	OF	23	478		40		23	170		35	
All	CF	2253	4632	n/a	60	n/a	1833	220	n/a	109	n/a
	OF	190	369		41		177	181		63	

the purchased concentrate cost, fertiliser cost and crop protection cost divided by the UAA (ha). This value was utilised to identify intensive, high input farms compared with more extensive production systems which are generally believed to have lower environmental impact (EEA, 2005) although they may also have lower yields and so figures per product may be less favourable.

Table 7 suggests that pig and poultry farms are particularly intensive, followed by horticultural farms, whereas LFA grazing livestock farms are much less intensive production systems and therefore may have lower environmental impacts.

It can be seen from the table that, in general, there were significant differences in the intensification indicator between organic and conventional farms, with conventional farms generally appearing to be more intensive than organic farms.

Agri-environmental scheme payments per UAA

Data for this variable were more evenly distributed than those for some of the other indicators e.g. fertiliser, with few outliers due to the limited value any one farm may receive through agri-environment schemes. The comparison between conventional and organic farms revealed that organic farms obtain a higher level of agri-environment scheme payments suggesting that there is more enthusiasm for scheme participation or that more schemes are suited to organic farming.

Considering farms by robust type (Table 8), it can be seen that horticultural, pig and poultry farms received the lowest level of payments; cereal, general cropping, lowland grazing livestock and LFA grazing livestock holdings received the highest levels, contrasting strongly with minimal payments on horticulture, pig and poultry holdings.

Statistically, organic and conventional farms were significantly different at the 0.5% level for all farm types except horticulture, with organic farms receiving significantly higher agri-environment payments (Table 9). For horticultural holdings the results were less significant with both organic and conventional horticultural farms receiving low levels of payments under these schemes.

Table 7: Statistical results for the intensification indicator (£/ha UAA).

Farm type		sample	mean	t-test	median	Mann-Whitney
Cereals	CF	356	279	***	274	***
	OF	17	18		8	
General cropping	CF	197	344	N.S	312	***
	OF	12	265		40	
Horticulture	CF	200	6967	N.S	838	**
	OF	10	3783		143	
Pigs	CF	54	26627	n/a	3886	n/a
Poultry	CF	52	164786	n/a	8720	n/a
Dairy	CF	397	828	***	755	***
	OF	51	529		490	
LFA grazing livestock	CF	525	153	***	127	***
	OF	41	68		51	
Lowland grazing livestock	CF	253	235	N.S	132	***
	OF	32	32		13	
Mixed	CF	185	436	N.S	216	***
	OF	23	497		73	
All	CF	2253	5381	n/a	273	n/a
	OF	190	577		63	

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Table 8: Statistical results for agri-environment scheme payments over UAA (£/ha):

Farm type		sample	mean	t-test	median	Mann-Whitney
Cereals	CF	356	39	***	30	***
	OF	17	144		119	
General cropping	CF	197	34	***	29	***
	OF	12	86		76	
Horticulture	CF	200	10	N.S	0	**
	OF	10	34		0	
Pigs	CF	54	24	n/a	0	n/a
Poultry	CF	52	14	n/a	0	n/a
Dairy	CF	397	24	***	20	***
	OF	51	85		61	
LFA grazing livestock	CF	525	37	***	30	***
	OF	41	126		93	
Lowland grazing livestock	CF	253	40	***	29	***
	OF	32	116		90	
Mixed	CF	185	38	***	30	***
	OF	23	87		70	
All	CF	2253	32	n/a	26	n/a
	OF	190	102		80	

Shannon crop diversity index

It has been postulated by some authors that greater cropping diversity (i.e. a greater range of crops being grown on the farm and a wider range of varieties within a crop) is associated with greater biodiversity in general (supporting a wider range of pollinators, and farmland birds, for instance) or with greater provision of ecosystem services and so has a positive environmental impact (Altieri, (1999); Hajjar *et al.*, (2008)). One suggested means of assessing the cropping diversity on a farm is to use the Shannon index.

A higher Shannon index value is indicative of a more diverse range of crops. A farm with several small fields of different crops but a large proportion of one crop will have a lower Shannon diversity index than a farm with the same number of crops evenly divided across the farm.

The formula used to calculate the Shannon index in this study is very basic being based on nine widely grown crops, two of which (horticulture crops and permanent pasture) are categories for a number of different crops.

The results shown in Table 9 suggest that the highest index values, and greatest cropping diversity, occurred on general cropping farms, followed by cereals farms and mixed farms. The lowest cropping diversity, as might be expected occurs on grazing livestock farms (which would be expected to mainly consist of permanent grassland). For the majority of the farm types there is no significant difference between organic and conventional farms. For mixed farms and lowland grazing livestock farms there was a significant difference with organic farms having a lower index suggesting that they have lower diversity in the crops considered here than conventional farms. These results will be discussed later, in particular evaluating what they imply with regards to using this kind of index based on financial information.

Grazing livestock units per forage grazing

This indicator gives an indication of the amount of pressure on the grazing land and the reliance of the farm on external inputs.

Table 9: Statistical results for the Shannon crop diversity indicator

Farm type		sample	mean	t-test	median	Mann-Whitney
Cereals	CF	356	1	*	1.05	N.S
	OF	16	0.81		0.69	
General cropping	CF	196	1.14	N.S	1.19	N.S
	OF	12	1.04		1.00	
Horticulture	CF	201	0.1	N.S	0.00	N.S
	OF	10	0.13		0.00	
Pigs	CF	42	0.28	n/a	0.00	n/a
Poultry	CF	35	0.11	n/a	0.00	n/a
Dairy	CF	387	0.18	N.S	0.00	N.S
	OF	50	0.15		0.00	
LFA grazing livestock	CF	524	0.03	N.S	0.00	*
	OF	41	0.05		0.00	
Lowland grazing livestock	CF	251	0.14	***	0.00	***
	OF	32	0.01		0.00	
Mixed	CF	185	0.78	***	0.75	***
	OF	23	0.51		0.58	
All	CF	2209	0.4	n/a	0.00	n/a
	OF	188	0.26		0.00	

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Table 10: Statistical results for grazing livestock units per forage area (grazing LU/ha)

Farm type		Sample	Mean	t-test	Median	Mann-Whitney
Dairy	CF	397	2.13	***	2.06	***
	OF	51	1.47		1.39	
LFA grazing livestock	CF	525	1.02	***	0.95	*
	OF	41	0.81		0.77	
Lowland grazing livestock	CF	253	1.56	*	1.3	***
	OF	32	0.92		0.83	
Mixed	CF	182	1.6	N.S	1.24	***
	OF	23	0.91		0.91	
All	CF	2111	1.2	n/a	1.02	n/a
	OF	185	0.97		0.97	

It can be seen from the results in Table 10 that LFA grazing livestock farms had the lowest stocking density, followed by lowland grazing farms and then dairy farms. There was a significant difference between all organic and conventional farm types with organic farms having lower stocking densities for all farm types.

Summary and discussion of differences

The results of the Mann-Whitney U test comparing organic and conventional farms showed that there were statistically significant differences between organic and conventional farms in terms of input costs. Fertiliser and crop protection costs were significantly higher for all conventional farm types when compared with organic holdings, reflecting the lower use of external inputs within organic cropping systems. This might be expected due to the strong emphasis on reducing these inputs in the organic regulations (EC No. 834/2007 and several implementing regulations) and agrees with the results of a meta-analysis of several LCA (life cycle analysis) studies comparing the environmental impacts of organic and conventional farming (Mondelaers *et al.*, 2009a). Similarly, the IRENA intensification indicator indicated greater intensity for all conventional farm type median values, though t-test results were more variable. The results appear to confirm that in general, conventional farms tended to be more intensive than organic holdings.

With regards to purchased feed costs, significant differences between organic and conventional farms depended on the robust farm type. Purchased feed and purchased concentrate costs for dairy farms only showed differences of low statistical significance with organic farms having slightly higher costs per livestock unit. This was probably due to higher organic feed prices rather than higher usage. Nix (2011) quotes a price for concentrates for conventional dairy farming of £220 per tonne whereas Lampkin *et al.* (2011) quote a price range of £310–£400 for compound concentrate feeds for organic dairy farms. This difference in prices would be sufficient to explain the higher organic purchased feed cost in this study (especially given the low significance of the difference). It is not possible to confirm whether the differences are due to higher usage or higher feed cost using FBS data alone (it required additional information from farm management handbooks). This is one of the limitations of this form of analysis using costs as a proxy for physical amounts. However, by factoring in the average costs of organic and conventional feed for the year it is possible to convert these cost figures into approximate usage figures.

For lowland grazing livestock there was a stronger significance, with organic farms having lower purchased feed costs. This was also reflected in LFA grazing livestock farms although with a slightly lower significance. Given the emphasis in organic farming on home-grown feed and the farm being a closed system the expectation would be that in general organic farms would use less bought-in feed. Thus these lower purchased feed costs appear reasonable.

Dairy and lowland grazing livestock farms showed significant differences in stocking density between organic and conventional management with organic farms tending to have lower stocking densities, again this is in accordance with the organic regulations. LFA grazing livestock farm differences were only significant at the 5% level, perhaps reflecting the fact that such farms tend to be unable to support larger stocking densities regardless of management system. Again, these results would appear to be reasonable and so suggest that the indicator is valid and works as a good proxy for level of intensification.

The Shannon index results indicated that some types of organic farms (mixed and grazing holdings) appear to have less cropping variety than conventional holdings, contradicting the findings of Mondelaers et al. (2009a) that organic farms generally have high agri-biodiversity. As discussed previously, the Shannon crop diversity index was calculated using the crop fractions of a selection of crops and the denominator was taken as the total of these. It must, therefore, be considered that a farm with a zero index (i.e. if the only crop, from those considered, that it grows is for example permanent grass) signifies that it only has one of the crops considered. It may be that a large diversity of other crops is grown on the farm but were not considered here. Additionally, permanent grass may include a large number of species of grass, legumes and various herbs. This is not recorded in the FBS and so cannot be derived from the data. As stated by Magurran (2006) in discussing the Shannon index, 'A more substantial source of error arises when the sample does not include all the species in the community'. Thus, the fact that the FBS does not record crop varieties or break down permanent pasture into species means that the Shannon index calculated here is prone to issues. This highlights one important limitation of using FBS/FADN data to derive environmental indicators: The data are obtained

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for financial reasons and so may not contain all the information which would be desirable to measure environmental factors to best effect. This suggests that, while the other indirect indicators included in this study have proved to be useful and effective, this type of index requires more information than can currently be provided by financial surveys. Indeed as stated by Magurran (2006) there are concerns about using the Shannon index in an ecological context (due, in part, to its need to include all species in the community – often an unknown when ecological assessments are being carried out) and other measures of biological diversity and being used in preference to the Shannon index in these contexts.

4. Discussion and Conclusions

The indicators used in this study were selected because they are well-established environmental indicators which have been used in a number of previous studies (Corson *et al.*, 2010; Dennis, 2009; EEA, 2005; Westbury *et al.*, 2011) and have been shown to provide useful information on the environmental performance of farms. The aim of this study was to assess whether it was possible to derive these environmental indicators from the financial data contained within the Farm Business Survey database and to use them to compare the performance of organic and conventional farms. Only indicators that could be derived from FBS data or on-farm financial records were considered, because such data is recorded on a regular basis from a large number of farms and across a number of countries (FADN). Other indicators have been suggested by other authors (Cooper *et al.*, 2009; Halberg *et al.*, 2005b) but would not be possible to derive from financial data and so were not considered here.

Advantages and limitations in the use of FBS data for assessing environmental performance

This analysis found the use of FBS variables to provide indirect environmental indicators to be challenging at times but found that it could provide some useful indication of environmental performance (i.e. detecting statistically significant differences between farms managed under organic or conventional methods) as will be discussed in the next section. The Farm Business Survey is primarily designed to obtain financial data and so is not designed to provide environmental data, but it records some information which can be used as a 'proxy' for direct environmental measurements.

As was pointed out by Westbury *et al.* (2011) the FBS lacks information about environmental features (such as hedgerows), intensity of cultivation and management of grassland and this limits the type of environmental indicator that can be derived from the survey. Similarly the lack of information about crop varieties or the number of species present in permanent pasture was highlighted above as a limitation in trying to use the Shannon index with these data. If such elements were added to the FBS this would allow a greater range of indicators to be used.

The significant advantages of using FBS data include its sample size, historical database and ability to distinguish between organic and conventional holdings. However, one of the limitations of this type of analysis using FBS data is the lack of quantitative data for inputs. Prices may vary significantly between organic and conventional feeds (as shown by the dairy results in this study), fertilisers and crop protection products and so comparing the cost for organic farms to the cost to conventional farms or the costs of two different types of fertiliser does not necessarily equate to comparing physical quantities used, even within the same year. This use of cost as a proxy for physical quantities is more unreliable if comparisons are taking place over several years, e.g. if using the indicators to track changes in environmental performance over time. In this case standard costs or price index data would need to be used to derive physical quantities from cost as otherwise inflation and other price fluctuations would affect the results. In this case it would be more accurate to ascertain the proportion of different feeds, fertilisers, crop protection products used in each year and by different types of farms and to then combine this information with standard costs (i.e. costs which were pertaining for those products at that point in time), as carried out by Corson *et al.* (2010). By taking this approach it is possible to obtain a much more accurate estimate of physical inputs from cost data. Alternatively, Westbury *et al.* (2011) suggested that adding specific estimates of fertiliser and pesticide use per hectare to the data collected within the FBS would improve precision further.

The results presented here suggest that these indicators are identifying expected differences between organic and conventional farming (in a statistically significant manner) and so are potentially useful in assessing environmental performance. However, the limitations discussed in this section mean that some indicators cannot be derived using financial data.

At present the authors are not aware of any environmental surveys carried out on a large sample of farms (equivalent in scale to FADN) on a regular basis across all countries of the EU. Being able to use indirect indicators of environmental performance derived from FBS/farm accountant type data would therefore be very valuable. The FBS is part of the EU FADN and so indirect indicators derived from economic data can usually be used across the EU. Farm Business information is recorded annually in the UK and has been recorded for a number of years in most EU countries and so retrospective studies can be carried out using these data as well as tracking of current changes in management practices. Comparisons between countries are also possible. It is therefore of interest to test the validity of these indicators and to assess whether they can be effective in assessing environmental performance. This is discussed below.

Discussion of indicator results – verification of the indicators

The results presented here contrast with those of Westbury et al. (2011). They concluded that either agri-environment scheme participation was not always associated with better environmental performance or that FADN indicator data were not able to detect differences in environmental performance. In the

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current study, the FBS derived indirect environmental indicators detected statistically significant differences between organic and conventional holdings in line with the findings of Mondelaers et al. (2009) in a meta-analysis of research comparing the environmental impact of organic and conventional farming.

The results with regards to the Shannon index, while they may appear negative, are also important as they show that not all indicators developed in an environmental context can be derived from financial information, some are best suited to on-farm assessments or more detailed environmental surveys. However, the results of this study suggest that most of the indirect indicators investigated (with the exception of the Shannon index) can be used to assess some aspects of environmental performance and identify statistically significant differences between organic and conventional production. This suggests that they are sufficiently sensitive to differing management techniques to be used to assess some aspects of environmental performance. This means that annual economic surveys such as the FBS can be used to give some environmental information, tracking changes over time and comparing countries through the EU.

Policy and societal context

Many industries, including agriculture are currently coming under closer scrutiny as concerns grow about their impact on greenhouse gas emissions, and therefore climate change, biodiversity, water and air quality and use of scarce resources.

As a result of these public concerns over the environmental impact of agriculture there is increasing interest amongst policy makers in encouraging farmers to consider the environment and to provide environmental benefits /reduce negative environmental impacts of farming. As a result, agri-environment schemes to encourage environmental benefits through agriculture have operated in all EU countries. Beyond these schemes, there is current discussion over 'greening' of the CAP as part of the 2014–2020 reforms. This is likely to result in Pillar One changing from being a policy put in place to encourage high levels of food production to ease food security concerns to being a policy encouraging more environmentally friendly farming (beyond cross-compliance measures) by having 30% of Pillar One dependent on carrying out environmentally supportive practices defined in legislation (European Commission, 2011). To monitor such policy measures, governments require means of monitoring its impact and being able to make use of current surveys which are carried out across the EU as part of the FADN could be very valuable in this context. It would allow the basic environmental assessment of agriculture through indicators which do not require additional surveys and therefore additional funds at a time of financial austerity.

There is also a great deal of interest from consumers in the environmental impact of the food that they eat. Recent studies of the motivation of consumers of organic foods have found that motives include environmental concerns as well as personal motives such as perceived health benefits (Hughner *et al.*, 2007; Mondelaers *et al.*, 2009b; Zander and Hamm, 2010). The recently introduced LEAF (linking environment and farming) marque is further evidence of consumers' interest in the environmental impact of their food as is recent marketing of certain products such as Jordan's cereals based on their environmental credentials. Membership of LEAF and of the farm assurance scheme is recorded in FBS as is organic status making it possible to also use these sorts of indicators to see whether there are significant differences between these farms and farms which are not members of such schemes.

Conclusions and future work

It appears from the analysis presented here that it is possible to use financial survey data such as the FBS to provide indirect information on the environmental performance of farms and it is possible to provide comparisons across different types of farms and farming systems. Extending these indicators to FADN data at EU level could allow policy-makers to track performance of some key agri-environmental aspects, to help monitor the impact of policy decisions and of changes in farm management approaches (e.g. a change in the proportion of organic farms within a country, the impact of an increased emphasis on the environment within the CAP). Furthermore this type of approach could be extended and used by farm consultants/ managers to use financial information (usually recorded for taxation reasons) to assess some aspects of environmental performance on an individual farm or group of farms.

Indeed, as useful as individual indicators may be, it is possible that combining a range of indicators, such as the IRENA intensity indicator and others into an overall score that takes account of intensity, crop variation, variation in habitat and stocking rates, as well as agri-environment payments could provide an overall score, in a similar approach to that taken by Gomez-Limon and Sanchez-Fernandez (2010). Although an indirect measure of environmental performance may never achieve a perfect assessment a combined score could be weighted to reflect the relative importance of the various factors.

Ultimately, it would be very useful if physical quantities e.g. of fertilisers and concentrates were included in FADN data such as the FBS (the Northern Irish FBS already includes some physical quantities e.g. feedstuffs including concentrates), as this would allow more accurate input indicators to be derived. Also, if the CAP is given more environmental emphasis then the inclusion of additional direct environmental information in FADN data would be very helpful to researchers and policy-makers as was previously discussed by Westbury *et al.* (2011).

Notwithstanding the limitations mentioned earlier and these possibilities for future improvement to this approach, the results presented here show that it is possible to use indicators derived from financial information to give a reasonable and valid comparison of environmental performance.

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