Extended Abstract
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Paper/Poster Title	Socio-economic Characteristics of the Early Adopters of LESS technology

Abstract prepared for presentation at the 96th Annual Conference of the Agricultural Economics Society, K U Leuven, Belgium

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Abstract	*200 words max*
The agricultural sector has become a pre-dominant source of air and water pollution in many countries, and the loss of nutrients to the environment indicates farm input use inefficiency. Farmers can be slow to respond to environmental issues because of the high cost of abatement, the diffuse nature of agricultural emission and a higher dependency on natural resources. The Irish agricultural sector is no exception. Ireland is non-compliant with the EU National Emission Ceiling Directive for ammonia emissions. LESS is a promising strategy in abating ammonia emissions in cattle farms as identified in the Marginal Abatement Cost Curve (MACC). The current study employs Maximum Likelihood Estimates to identify the socio-economic characteristics of early adopters' of Low Emission Slurry Spreading (LESS) equipment. Teagasc National Farm Survey data for 2020 (N=810) is used for the analysis. In the sample, about 35.8% of the total respondents have adopted LESS technology. The variables used in the model include characteristics of the farmers, i.e. age, household size and characteristics of the farms, i.e. farmland area, type of enterprise, region, income per unit land area (EUR/ha) and stocking rate. A statistically significant ($p < 0.001$) logit model indicated a positive relationship between adoption of LESS equipment and enterprise type (being a dairy farmer), region, farm size and stocking rate. The log-likelihood of adopting LESS technology increases with farmers whose dominant enterprise type is dairy ($p<0.001$), have a higher commercial orientation ($p<0.001$), higher farmland area ($p<0.001$), and are located in the border region 1 ($p=0.001$).	

Keywords	Slurry spreading, LESS equipment, Ammonia abatement, Farmers, Dairy, Logit model, Maximum Likelihood Estimates, Binary choice Model, Ireland
JEL Code	Q16 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	*100 – 250 words*

Slurry spreading is an effective farm management practice in Ireland, currently increasing in importance as an alternative plant nutrient source because the increasing chemical fertiliser cost is forecasted to diminish the farms' net marginal return in 2022. However, the value of slurry diminishes with a high amount of nutrient loss, for example, N loss due to leaching, runoff and gaseous emissions. Method and timing of slurry spreading are crucial determinants of nutrient retention in soil. Therefore, the Department of Food, Agriculture and the Marine in Ireland launched the LESS equipment grant scheme to promote efficient slurry spreading systems in Ireland. Reducing ammonia emission is critical for the Irish livestock sector. Environmental Protection Agency (2020) reported that manure management, animal manure applied to soil, and nitrogen from grazing animals' urine and dung deposition collectively account for approximately 89% of the national ammonia emission. Meanwhile, Ireland is non-compliant with the Directive 2001/81/E.C. of the European Parliament relating to ammonia emission. Adopting LESS equipment such as slurry tanks with trailing shoe, dribble bar or band spreaders, shallow injection systems, and umbilical system

is a crucial strategy identified to achieve emission ceiling compliance in 2030 (Buckley et al., 2020).

Methodology *100 – 250 words*

The current study uses Teagasc National Farm Survey (NFS) data of the year 2020 to identify the socio-economic characteristics of the farmers who are adopting Low Emission Slurry Spreading (LESS) Techniques. Teagasc has conducted the National Farm Survey (NFS) on an annual basis since 1972. A random, nationally representative sample of approximately 900 farms is selected annually for this survey. The study uses descriptive statistics and Maximum Likelihood Estimation (MLE) to predict the binary dependent variable (adoption of LESS technology). The parameter estimates indicate the change in the log of the odds associated with a unit change in an independent variable when all the other conditions are held constant (Wooldridge, 2012).

The model uses the cumulative logistic function (logit model) depicted in equation one below for estimating the log-likelihood of adopting LESS technology.

$$L_i = ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 x_1 + u_i \quad Equation\ 1$$

Where;

$L_i = log\ value\ of\ the\ odds\ ratio$

Results *100 – 250 words*

Socio-economic characteristics of the participants

The total sample size is 810 farmers. About 35.8% of the total respondents have adopted LESS technology, 60 % received Teagasc advisory service, 32% were in the 61-70 age category, and 28% were in the 51-60 age category. The regional differences on average Farm Income (EUR/HA), Total Farmland (HA), Household Size, Respondents' Age and Stocking Rate are illustrated in Table 1. Accordingly, the highest average farm income is observed in regions 6 and 7, the most extensive farmlands are observed in Regions 3, and 7 and the highest average stocking rates are observed in regions 3 and 6.

Table 1: Descriptive Statistics

		N	Mean	Standard Deviation	Minimum	Maximum
Income (EUR/HA)	1	161	529.24	444.82	-319.90	2071.29
	2	4	542.93	207.87	324.28	730.50
	3	69	728.42	647.83	-228.38	2858.97
	4	108	543.85	578.10	-828.19	2825.65
	5	74	719.87	565.63	-212.00	2210.46
	6	158	946.49	692.21	-707.23	3143.73
	7	141	964.83	779.24	-744.13	5349.51
	8	89	534.64	424.07	-480.01	2261.49
Total Farmland (HA)	1	161	51.12	39.61	8.65	220.40
	2	4	58.16	29.90	14.50	79.80
	3	69	74.15	44.71	10.90	227.60
	4	108	68.38	42.48	7.70	225.00
	5	74	61.72	41.25	14.62	229.45
	6	158	61.06	38.49	11.10	233.91
	7	141	71.34	65.23	8.30	450.00
	8	89	45.17	44.67	11.47	413.60
Household Size	1	161	2.98	1.56	1	8
	2	4	1.50	.58	1	2
	3	69	2.78	1.42	1	8
	4	108	3.15	1.63	1	7
	5	74	2.96	1.42	1	7
	6	158	2.92	1.31	1	6
	7	141	2.92	1.35	0	6

	8	89	2.39	1.18	1	6
Respondents' Age	1	161	56.52	12.46	25	86
	2	4	64.50	14.48	48	82
	3	69	59.41	11.24	29	85
	4	108	59.91	11.10	31	84
	5	74	58.64	10.89	34	84
	6	158	58.10	11.05	30	80
	7	141	55.04	11.86	23	84
	8	89	59.96	10.66	37	82
Stocking Rate	1	161	1.42	.63	.00	4.20
	2	4	1.61	.89	.75	2.62
	3	69	1.84	.78	.00	4.84
	4	108	1.61	.61	.34	3.37
	5	74	1.57	.62	.32	3.22
	6	158	1.83	.63	.00	3.66
	7	141	1.67	.78	.12	4.59
	8	89	1.34	.53	.24	3.07

Furthermore, Table 2 depicts the socio-economic characteristics of the respondents based on adopting LESS technology (Binary response =1, for adopting, =0 for Not adopting). Accordingly, the average age of the farmers who adopted LESS technology is 55 years, their average farm income (Mean=1004.64 EUR/HA), farmland size (Mean= 73.56 HA), and stocking rates (Mean=1.92) are higher than those who did not adopt LESS technology.

Table 2: Descriptive Statistics According to Adopting LESS

(Yes= Adopting; No = Not adopting)

		Mean	Std. Deviation	Minimum	Maximum
Income (EUR/HA)	No	564.74	544.45	-707.23	5349.51
	Yes	1004.64	688.02	-828.19	3143.73
Total Farmland (HA)	No	53.69	44.33	7.70	413.60
	Yes	73.56	47.75	9.43	450.00
Household Size	No	3	1	1	7
	Yes	3	1	1	8
Respondents' Age	No	59	11	25	84
	Yes	55	12	1	86
Stocking Rate	No	1.43	.61	.00	4.84
	Yes	1.92	.68	.29	4.20

Maximum Likelihood Estimation (MLE) for adopting LESS Technology

The results are summarised in Table 3. Accordingly, higher stocking rate, being a dairy farmer, being locating in region one and larger farm size positively influence the adoption of LESS technologies.

Table 3: Adoption of LESS Technology, Binary logit model estimates

		Adjusted p-value
(Intercept)	-2.819	0.000
[D_FARM_REGION_CODE=1]	1.129	**0.001**
[D_FARM_REGION_CODE=2]	0.442	0.716
[D_FARM_REGION_CODE=3]	0.484	0.245
[D_FARM_REGION_CODE=4]	-0.625	0.125
[D_FARM_REGION_CODE=5]	-0.621	0.153
[D_FARM_REGION_CODE=6]	-0.061	0.867
[D_FARM_REGION_CODE=7]	-0.009	0.981
[D_FARM_REGION_CODE=8]	0[a]	.
Advisory Participation	0.074	0.685
Income (EUR/HA)	0.000	0.166
Total Farmland (HA	0.008	**<0.001**
Household Size	0.059	0.394
Respondents' Age	-0.008	0.362
Stocking Rate	0.626	**<0.001**
Dairy Dummy	1.330	**<0.001**
(Scale)	1[b]	

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Discussion and Conclusion

100 – 250 words

The LESS equipment grant scheme is provided by the Irish Department of Food, Agriculture and the Marine to promote use of slurry tanks with trailing shoe, dribble bar or band spreaders, shallow injection systems, and umbilical system for slurry spreading and discourage use of splash spreading. Furthermore, from January 2021, using LESS equipment is mandatory for farms under nitrates derogation in Ireland (DAFM, 2021). LESS equipment reduces the spread width compared to splash spreading, minimises exposure to the surface area, reduces emission and applies slurry near grassroots (Donnelly, 2021). The current study examines the farmers' socio-economic factors who are the early adopters of LESS technology in Ireland. The Maximum Likelihood Estimates for the binary dependent variable (1= Adopting LESS; 0= Not adopting LESS) shows that the level of farm management or commercial orientation indicated by the stocking rate, type of agricultural production (binary variable 1= dairy, 0= other enterprises; other cattle, sheep, horse, tillage), geographic location (Region 1) and farmland area are statistically significant ($p<0.001$) determinants that increases the likelihood of the early adoption of LESS technology in Ireland. This analysis indicates farmers with bigger and more profitable farms are highly likely to adopt environmentally oriented technologies when a government support scheme is available.

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