Short communication

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The state of innovation in European agriculture: Innovators are few and far between

Innovation and adoption of innovation are considered key indicators of competitiveness and sustainability. Analysing data from 821 farms from eight Member States of the European Union in the frame of the EU Framework 7 project FLINT, this study provides an insight into the different adoption rates of five types of innovation in agriculture across Europe and suggests the potential effects of different factors, including farm type and farm size, subsidies and age, on farmers' decision to innovate.

Keywords: farm-level, FADN, EU Member States

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Introduction

Innovation is seen as one of the key drivers for a competitive and sustainable agriculture. It is often hypothesised to be influenced by numerous determinants. For example, Diederen *et al*. (2003a) find that innovation adoption is positively related to labour resources, market position, access to information and past adoption behaviour, and negatively to solvency and the degree of market regulation. Next to the structural characteristics traditionally used in decision-theoretic models, such as farm size, market position and solvency, Diederen *et al*. (2003b) also used behavioural variables that reflect mainly the searching for, handling of and sharing of information.

In contrast to farm competitiveness, we are not aware of any in-depth study on the impact of innovation on the sustainability of farming in European Union (EU) Member States. The lack of data on the state of innovation hampers such studies. Against this background, the EU Framework 7 project FLINT[3] collected farm-level indicators on innovation and related aspects in nine EU Member States. In this paper, in combination with data collected by the Farm Accountancy Data Network (FADN)[4], the FLINT data are used to obtain insight into different adoption rates and determinants of adoption of five types of innovation in agriculture across Europe.

Methodology

The economic size and type of farming are two of the most important structure characteristics of farms. Following the hypothesis that farmers with larger business are more likely to adopt relatively new innovations, we examined the level of innovation across different farm size classes. With regard to the type of farming, the hypothesis is that farmers that produce for heterogeneous markets are likely to adopt innovations earlier. Based on Eurostat's farm typology, farms in horticulture and vegetables produce for more heterogeneous markets than those in dairy and meat.

The analysis in this paper is based on data from 821 farmers collected in eight EU Member States. The FADN and FLINT data relate to accountancy year 2015, except for France and Germany for which it is 2014. Adoption of different types of innovation is analysed as a discrete choice problem. Considering the nested nature of farm data within farming types and Member States, multi-level mixed-effects probit models were used to estimate the fixed effects of a set of explanatory variables and random effects that are associated with factors related to farming type and Member State. The model is estimated using the meprobit procedure of Stata® (13.1)[5] with Member State and farming type as the two levels with random intercepts. The five types of innovation indicators and one aggregated indicator distinguished in the dataset are:

- Product innovation that is new for the company within the last three years, but not new to the market (*product not new*);
- Product that is new to the market (*product new*);
- Process innovation that is new for the company within the last three years, but not new for the market (*process not new*);
- Process innovation that is new for the company and new for the market (*process new*);
- Market and organisational innovation (*organisational*);
- Having one or more of the above-mentioned types of innovation (*farms with innovations*).

Results

The general state of innovation

The state of innovation as shown by the adoption rates of different types of innovation varies greatly across the eight Member States in the survey (Table 1). On average, about 41 per cent of the farms have innovated in one or more of the five types of innovation within the last three years. The level of innovation is high in Finland, Germany, Hungary, Poland and Greece. In all eight Member States except Finland, most farms innovate in processes that are not new to the market. Within product and process innovation, the FLINT data make a comparison between new for the market (innovators) and not new for the market (early and late adopters) possible.

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[5] http://www.stata.com/manuals13/memeprobit.pdf

Table 1: Adoption by type of innovation and number of observations per Member State.

Member State	Product new	Product not new	Process new	Process not new	Organisational	Farms with innovation	Number of observations
	Per cent of all farms						
Finland	2	12	8	32	36	56	50
Germany	6	17	2	31	31	52	52
Greece	1	16	0	44	7	50	124
Hungary	3	17	1	41	20	52	102
Ireland	0	0	0	2	0	2	65
Netherlands	2	5	4	17	16	32	155
Poland	0	24	0	40	10	52	146
Spain	3	12	2	25	9	33	128
Total sample	2	13	2	30	14	41	821

Source: own data

Table 2: Adoption by type of innovation and number of observations per farm size class.

Farm economic size class	Product new	Product not new	Process new	Process not new	Organisational	Farms with innovation	Number of observations
	Per cent of all farms						
3	0	0	0	22	6	22	18
4	0	15	0	24	4	29	55
5	0	15	0	29	6	37	65
6	4	18	2	36	11	46	143
7	3	18	1	31	16	46	159
8	1	10	1	24	16	37	185
9	1	10	2	33	13	44	87
10	0	15	0	44	24	56	34
11	0	0	0	33	22	44	18
12	9	5	9	18	9	23	22
13	8	19	12	31	27	50	26
14	0	17	0	50	33	67	6
Total sample	2	13	2	30	14	41	819

Source: own data

Table 3: Adoption by type of innovation and number of observations per type of farming.

Type of farming	Product new	Product not new	Process new	Process not new	Organisational	Farms with innovation	Number of observations
	Per cent of all farms						
Specialist field crops	2	20	1	36	15	48	179
Specialist horticulture	8	19	6	11	17	36	36
Specialist permanent crops	0	23	0	47	16	58	104
Specialist grazing livestock	2	8	3	21	13	33	313
Specialist granivores	0	12	1	25	10	36	77
Mixed cropping	5	14	0	18	14	32	22
Mixed livestock holdings	0	0	0	44	11	44	9
Mixed crop – livestock	3	10	0	43	14	48	79
Total sample	2	13	2	30	14	41	819

Source: own data

Innovators are few and far between compared to early and late adopters. The percentage of innovators on product and process is overall around 2 per cent, which is much lower than the early and late adopters.

Innovation and structural characteristics of farms

A higher percentage of larger farms (size classes 12 and 13; Standard Output between EUR 1,000,000 – 3,000,000 per year) innovated in new products and new processes (Table 2). Organisational and market innovations are also more frequently adopted on the largest farms (size classes 13 and 14; Standard Output EUR 1,500,000 and higher). Adoption of innovations in product and process that are not new to the market seems to be less dependent on farm size.

Specialist farms in permanent and field crops and mixed farms (crops and livestock) have the highest percentage of innovation. Organisational and market innovations are quite homogeneous between the different farm types (Table 3). In horticulture, most innovations took place for new products and processes.

Determinants of innovation based on multi-level mixed effect logistic regression

The estimated coefficients of the explanatory variables of the regression analysis suggest that farm type and farm size are likely to be the main determinants of process and organisational innovation (Table 4). Subsidies appear to have a significantly positive effect on the adoption of process innovation. Other explanatory variables included are farmer age and the number of advisory contacts by the farmer in a year. This latter information is derived from the FLINT database. Farms with younger holders are in general more likely to innovate.

Among financial indicators of the farm, farm net income has a positive effect on production innovation and organisational innovation and appear to have a negative, albeit not significant, effect on process innovation. Somewhat surprisingly, high cash flow seems to have a negative effect on innovation in general and on organisational innovation in particular. This might be explained by the fact that farms with high cash-flow are likely to be more conservative in taking on innovations.

Table 4: Estimates of the adoption models (parameters are odds ratios and standard errors) for innovations.

Variable	Product not new	Product new	Process not new	Process new	Organisational	Farms with innovation
Fixed effects						
Economic size class	0.0422 (0.0508)	0.0859 (0.0922)	0.131*** (0.0466)	0.103 (0.0756)	0.0806* (0.0489)	0.0940** (0.0417)
Farm net income	2.29e-06** (1.07e-06)	2.19e-06 (1.50e-06)	-2.42e-07 (8.41e-07)	-1.05e-06 (1.07e-06)	1.88e-06** (8.06e-07)	1.63e-06* (8.54e-07)
Total subsidies	1.73e-06 (1.98e-06)	3.66e-07 (3.22e-06)	4.06e-06** (1.73e-06)	3.97e-06** (1.92e-06)	-1.75e-06 (1.94e-06)	1.91e-06 (1.85e-06)
Total liabilities	-2.12e-07 (1.40e-07)	-1.39e-07 (3.43e-07)	-1.85e-07 (1.37e-07)	1.41e-07 (1.56e-07)	9.50e-09 (1.16e-07)	-4.64e-08 (1.22e-07)
Total assets	3.96e-10 (6.74e-08)	-1.19e-07 (1.86e-07)	8.92e-08 (5.67e-08)	1.72e-08 (9.12e-08)	1.47e-08 (5.71e-08)	8.65e-08 (6.03e-08)
Cash flow	-5.60e-07* (3.37e-07)	-3.65e-07 (4.49e-07)	-1.77e-07 (2.60e-07)	1.89e-07 (3.59e-07)	-6.28e-07* (3.22e-07)	-6.58e-07** (2.73e-07)
Farmer's age	-0.0127** (0.00638)	-0.0165 (0.0124)	-0.0116** (0.00506)	-0.0252** (0.0127)	-0.0234*** (0.00623)	-0.0175*** (0.00485)
Advisory contacts	-0.0113 (0.00958)	0.00205 (0.0136)	0.0176*** (0.00664)	-0.00383 (0.0135)	-0.00925 (0.00951)	0.0115* (0.00651)
Constant	-0.913* (0.509)	-2.025** (0.855)	-1.256*** (0.461)	-1.888** (0.811)	-0.639 (0.482)	-0.321 (0.438)
Random effects						
Member State	0 (0)	0 (0)	0.270 (0.194)	0 (0)	0 (0)	0.340 (0.247)
Type of farming	0.453** (0.197)	0.148 (0.213)	0.0736 (0.0649)	0.0156 (0.118)	0.318** (0.144)	0.0750 (0.0582)

Number of observations = 782; number of groups = 8; standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Source: own data

Discussion

Owing to the lack of empirical studies in other countries, the results of this study should be interpreted as indicative and with caution. The case that most innovations took place in process innovation was also found in Dutch and Flemish FADN surveys (Diederen *et al*., 2003b; Deuninck *et al*., 2008; van der Meer and van Galen, 2016).

For the Netherlands, a comparison can be made between our results and those of the farm-level innovation monitor. This panel data set covers the period from 2005 onwards. In 2014 about 2 per cent of Dutch farmers (including horticulture) were innovators and 16 per cent could be seen as early or late adopters. The proportion of innovators in agriculture has been fluctuating for several years around 2 per cent. Since 2011 the proportion of early or late adopters has been increasing (van der Meer and van Galen, 2016). The Dutch FLINT results are consistent with these results. Relatively small deviations could be explained by the definition of innovation. In the innovation monitor the question is about an innovation that took place in the last year where as in the FLINT project this period is three years.

Our finding that the age of the farmer is a determinant of innovation may be linked to the fact that older farmers have, on average, a lower level of education, which may be correlated with the ability to judge opportunities to innovate. They may also have a shorter time horizon and be less inclined to invest in novelties. Schnitkey *et al*. (1992) argued that age is related to farm expertise. They will rely less on external information, and therefore do not get in touch with innovations in the market as early as their younger colleagues (Diederen *et al*., 2003b).

Continuing data collection on innovation for several years will enable to determine the trends in adoption rates. The integrated character of the FLINT+FADN database allows economic, social and environmental aspects of farming to be combined. For policy analyses, time-series of innovation indicators are a step forward for estimating the net impacts and establishment of counterfactuals on the long term.

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