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Diminished work ability as a contributing factor for farmer's interest in switching to organic production

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Abstract. Previous studies suggest organic producers have diminished work ability, but it is unclear if this is due to pre-existing conditions or work exposures in organic production itself. The current study explored whether diminished work ability is a contributing factor to the interest in switching from conventional to organic production. The study used data from 2018, Finnish farmer questionnaire, analysed by machine learning - based approach and logistic regression modelling. Nearly half (46%) of the survey respondents (n = 2,948) had a diminished work ability score. Seventeen percent (n = 501) of the respondents reported being interested in switching to organic production. Farmers with diminished work ability had greater odds (OR 1.56, 95% CI: 1.26–1.92) for showing interest in switching. Those growing horticulture and special crops (vs. cereals) (OR 0.55) and those age 55+ years (vs. less than 35) (OR 0.51) showed less interest in switching. The interest in starting or expanding organic production was higher among those who already had an organic agreement on part of their farm (OR 5.7) and those who had other business activities on the farm (OR 1.36). In summary, this study suggests that diminished work ability predicts farmer's interest for switching to organic production. Measures to protect the health and well-being of farmers and workers during and after switching to organic production is critically important in achieving not only policy goals to increase organic production, but also good quality of life of farmers.

Key words: agriculture, logistic regression, machine learning, social sustainability, well-being at work.

INTRODUCTION

Well-being at work is an essential value expressed by farmers, and it is also one of the criteria in assessing the success of farm production (Mattila et al., 2008; Karikallio & Lahnamäki-Kivelä, 2023). Resilient food system requires strong social support, which is reflected in the EU's Farm to Fork strategy and social conditionality reform (European Commission, 2020).

Work ability is a widely used indicator for measuring well-being at work in many industries (Alavinia et al., 2007; Sell et al., 2009; Karttunen & Rautiainen, 2011; von Bonsdorff et al., 2011). It is based on theory that work ability reflects the balance between work demands and worker's resources (Ilmarinen 2006; Gould et al., 2008). Diminished work ability is more prevalent among farmers compared to other entrepreneurs or salaried workers (Saarni et al., 2008) indicating that the imbalance between worker resources and work demands is more frequent in farming than in other occupations (Gould et al., 2008). While the physical and mental health of an individual is an important element in determining work ability, it can also be influenced by skill development, motivation, work tasks, work environment and work management, as well as by family relationships and the surrounding community (Ilmarinen 2006; Gould et al., 2008). Reduced work ability is a strong predictor of increased sickness absence, disability pension, and mortality rate (Kujala et al., 2006; Alavinia et al., 2007; Sell et al., 2009; von Bonsdorff et al., 2011).

In Europe, the transition to organic production is seen as an important way to maintain biodiversity, combat environmental degradation, and to improve the welfare of farmed animals. The EU goal is to have 25% of agricultural land in organic production by 2030 (European Commission, 2020). In Finland, the area under organic production has been increasing, but is still far from the goal; in 2010, 3,939 farms (6.1% of all farms) and 7.5% of agricultural land were in organic production; in 2023, the respective figures were 4,153 farms (9.8% of all farms) and 13.7% of agricultural land (Finnish Food Authority, 2025). In addition to the environmental considerations, farmers are motivated to switch by the expected greater financial rewards in organic production (Pietola & Lansink, 2001; Karali et al., 2014; Trujillo-Barrera et al., 2016). Higher agricultural subsidies, premium prices, and lower production costs in organic farming may result in better profitability compared to conventional farming (Koikkalainen et al., 2011; Crowder & Reganold, 2015). Moreover, the productive performance of the Finnish organic farms has improved over the years (Kuosmanen et al., 2021).

Dessart et al. (2019) identified several behavioral factors that affect farmers' willingness to adopt sustainable farming practices, for example choices of neighboring farmers, opinions and actions of social referents, and a possibility to gain social status. Cranfield et al. (2010) highlighted that health and safety concerns also have a significant impact on farmers' willingness to switch to organic production. Some studies have reported that organic farming may have a positive impact on occupational health and safety of farmers and farm workers. Smit et al. (2007) found that organic farmers reported less wheezing with shortness of breath but found no effects of farming practices (organic/conventional) for asthma. Cross et al. (2008) found some indication of better mental health of workers on organic farms; however, three out of four measurements did not indicate differences between organic and conventional farms. Mzoughi (2014) found a positive impact of organic farming on life satisfaction whilst Khan et al. (2018) reported that organic farmers had less neurological symptoms than conventional farmers.

In our earlier studies among Finnish farmers, we have found no evidence that organic farming would have beneficial effects on occupational health and safety of farmers; including no differences in mental and musculoskeletal health symptoms (Mattila et al., 2022). Exposure to poisonous and irritating substances was less frequent, while exposure to vibration and mold was more frequent on organic farms (Mattila et al., 2022). Further, organic production had a negative association with work ability, i.e., diminished work ability was more prevalent among farmers practicing organic farming

(Mattila et al., 2020). However, these studies could not establish whether diminished work ability existed already before switching to organic production or developed after, due to organic farming exposures. Understanding this is essential for targeting preventive and well-being measures at work effectively.

The aim of the current study was to evaluate whether diminished work ability is a contributing factor to the interest in switching from conventional to organic production while controlling for sociodemographic and farm-related factors.

MATERIALS AND METHODS

This study was based on farm survey data collected by Kantar TNS Agri Oy in 2018 for the Finnish Ministry of Agriculture and Forestry. The survey, focusing on farm development plans, has been repeated every second year since 2006 with minor changes. Questions about work ability were included in the survey for the first time in 2018. Data collection was carried out using an online system and phone reminders. The survey sampling frame included all organic farms, all pig, poultry (with a minimum 100 chicken), sheep, and bovine farms, random sample of potato farms (500 farms, farm size over 1 ha), all sugar beet farms, random sample of field vegetable farms (600 farms, farm size over 1 ha), random sample of field berry farms (600 farms, farm size over 1 ha), random sample of crop farms (8,000 farms, farm size over 2 ha), all horse farms, and random sample of other plant production farms (1,000 farms). Crop, horticulture and other plant production farms were included in the sampling frame only if they had an email address. The selected animal farms were included even if they had no email address, in which case they were contacted by phone. The response rate was 17%: 4,442 farms in total, of which 3,739 were in conventional and 703 in organic production. After excluding farms that did not meet our analysis inclusion criteria, such as fully organic farms and farms with unclear organic status, our subset consisted of 2,948 valid observations (with no missing data).

Outcome variable

At the time of the survey in Finland, farmers were permitted to be partly in organic production, for example, have organic crop production whilst animal production was carried out by conventional methods. Therefore, the questions addressed each specified production sector separately, including interested in switching to organic production. The specified production sectors were dairy, beef, suckler cows/calves, suckler cows/slaughter animals, pork, egg, sheep, field vegetable, field berry, and plant production. Fully conventional farms were included in the analysis, and farms with no conventional production (i.e. fully organic or in the transition period) were excluded. Partly organic farms were included in the analyses; they are a special group that has already knowledge and experience of organic rules and methods.

The farmers were coded by interest in switching to organic production. Those answering ‘interested in switching to organic production’ in any of their specified production sectors they were coded as ‘Yes’ (for interested in switching). Otherwise, they were coded as ‘No’, not interested in switching to organic production. The distribution of the dichotomized outcome variable ‘interested’ is shown in Table 1.

Potential predictors

Work ability can be analyzed using several different methods. In Finnish population-based studies, the most typically used indicators are the Work Ability Index WAI), Work Ability Score (WAS), and Work Ability Estimate (Gould et al., 2008). In our study, we used the Work (Ability Score, which is a single question method in which a farmer self-assesses their current work ability compared with their lifelong best on a scale of 0 to 10. The English translation of the question used in the study was: 'On a scale of 0–10, how would you rate your current work ability? 0 means that you are currently unable to work at all and 10 that your ability to work is at its best'. The WAS is known to be strongly correlated with the Work Ability Index, which includes a large set of questions (Ahlström et al., 2010). El Fassi et al. (2013) recommends using the WAS method because of its user-friendliness, and satisfactory validity compared with the WAI index. In addition to work ability, potential predictors were related to farm and farmer characteristics, the farm's financial situation, and farm management choices (Tables 2–4).

Table 1. Frequencies of 'interested in switching to organic production' response variable

Classes of the 'interested' response variable	Class description	*n*	%
Yes	Farmers interested in switching to organic production	501	17
No	Farmers with no interest in switching to organic production	2,447	83
Total		2,948	100

Table 2. Description of the potential predictors for interest in starting organic production

Potential predictor	Categories	Description
Work Ability Score (WAS)	Declined Good	Farmer's own assessment of his/her current work ability compared with their lifelong best on a scale of 0 to 10, where 8–10 indicates good, and 0–7 declined, work ability
Main production sector	Crop production, Horticulture and special plants, Other plant production, Animal production	The main production sector of the farm based on the farmer's assessment
Farm size	<3 0 30–49 50–69 70+	Hectares of farmland (1 hectare = 2.47 acres)
Age	< 35 35–44 45–54 55+	Age of the farmer, years
Training	No Yes	Yes, if the farmer has received any training or advice on the specified topics[1]

Table 2 (continued)

Paid wage work	Yes No	Yes, if the principal farmer regularly works outside the farm either full-time or part-time
Profitability	Good Satisfactory Poor	Profitability of farming based on the farmer's assessment
Indebtedness	Not at all < 50,000 50,000–199,999 200,000+ Not known	Debt of farm business, €
Farm succession	Yes, certainly Yes, possibly No Not currently relevant	Do you have a successor who will continue production on your farm?
Organic agreement	No Yes	Yes, if part (but not all) of the production is already organic. The organic agreement is a commitment to follow rules of organic production and is a prerequisite for the organic production subsidies
Other business	No Yes	Yes, if the farmer had any other business activity in addition to basic agriculture in 2017
Developing crop farming	1…45	Adoption of practices to develop crop farming. Sum of responses to nine different actions[2] on a 5-point Likert scale: 1 = not at all….5 = very much

[1] Specified topics: finance; management and planning; marketing; risk management; feeding and animal care; silage production; other field cultivation; subsidies; computer and digitization skills; well-being at work; time management; employer skills; energy and environmental issues; inception of business operations; direct marketing and selling; food legislation.

[2] The specified actions were: production of crops (yield and quality) corresponding to market demand; knowledge of yields and production costs (€/tonne); use of risk management tools for crop production; improving the effectiveness of the use of nutrients by dividing the fertilization in the growing period; improving the crop yield by intensifying plant protection; basic improvements to fields like draining and liming; follow-up of mold toxins and contributory factors; use of early varieties for risk management; diversifying of cultivation using crop rotation and new plants for example.

The analysed data included 2,948 valid responses from Finnish farmers. Forty-six percent (1,366 farmers) of them had diminished work ability, and 54% (1,582 farmers) good work ability (Table 3). Seventeen percent (501 farmers) were interested in switching their farm to organic production, and 11% (54 farmers) of them had already partly followed organic production rules (Table 3).

Out of farmers expressing an interest in switching to organic production, 50% had declined work ability, 48% had animal farms, and 39% had farm size over 70 ha. They were most typically 45–54 years old, 89% had received training or advice in key topics, and most (69%) had no salaried work outside farming, but 58% had other business activities in addition to basic agriculture (Table 3). Profitability of these farms was typically (53%) on a satisfactory level and debt of farm business was between 50,000–199,999 € (Table 3).

Table 3. Frequencies of the potential class-scale predictors. The total number of persons $N = 2{,}948$

Potential predictor	Interest in switching to organic farming		
	No, *n* (%)[a]	Yes, *n* (%)[a]	Total, *n* (%)[1]
Work ability			
Declined	1,117 (46%)	249 (50%)	1,366 (46%)
Good	1,330 (54%)	252 (50%)	1,582 (54%)
Main production sector			
Crop production	815 (33%)	176 (35%)	991 (34%)
Horticulture and special plants	298 (12%)	40 (8%)	338 (11%)
Other plant production	290 (12%)	46 (9%)	336 (11%)
Animal production	1,044 (43%)	239 (48%)	1,283 (44%)
Farm size			
< 30	805 (33%)	119 (24%)	924 (31%)
30–49	488 (20%)	107 (21%)	595 (20%)
50–69	350 (14%)	79 (16%)	429 (15%)
70+	804 (33%)	196 (39%)	1,000 (34%)
Age			
< 35	157 (6%)	58 (12%)	215 (7%)
35–44	430 (18%)	112 (22%)	542 (18%)
45–54	799 (33%)	176 (35%)	975 (33%)
55+	1,061 (43%)	155 (31%)	1,216 (41%)
Training			
No	270 (11%)	53 (11%)	323 (11%)
Yes	2,177 (89%)	448 (89%)	2,625 (89%)
Paid wage work			
Yes	701 (29%)	157 (31%)	858 (29%)
No	1,746 (71%)	344 (69%)	2,090 (71%)
Profitability			
Good	332 (14%)	61 (12%)	393 (13%)
Satisfactory	1,281 (52%)	264 (53%)	1,545 (52%)
Poor	834 (34%)	176 (35%)	1,010 (34%)
Indebtedness			
Not at all	683 (28%)	92 (18%)	775 (26%)
<5 0,000	600 (25%)	132 (26%)	732 (25%)
50,000–199,999	567 (23%)	147 (29%)	714 (24%)
200,000+	541 (22%)	121 (24%)	662 (22%)
Not known	56 (2%)	9 (2%)	65 (2%)
Farm succession			
Yes, certainly	261 (11%)	38 (8%)	299 (10%)
Yes, possibly	698 (29%)	194 (39%)	892 (30%)
No	793 (32%)	84 (17%)	877 (30%)
Not currently relevant	695 (28%)	185 (37%)	880 (30%)
Organic agreement			
No	2,398 (98%)	447 (89%)	2,845 (97%)
Yes	49 (2%)	54 (11%)	103 (3%)
Other business			
No	1,282 (52%)	211 (42%)	1,493 (51%)
Yes	1,165 (48%)	290 (58%)	1,455 (49%)

[1] Percentages add up vertically in columns.

Table 4 gives the descriptive statistics for the variable 'developing crop farming' which is a sum of responses to nine different key actions explained in the Table 2. Both median and mean figures were a bit higher for those farmers who did not express interest in switching to organic farming (Table 4).

Table 4. Descriptive figures of the potential predictor 'developing crop farming'

	Interest in switching to organic farming	
	No	Yes
Developing crop farming		
Min	3.00	2.00
1st Q	15.00	15.00
Median	19.00	18.00
Mean	20.16	18.33
3rd Q	23.00	21.00
Max	45.00	45.00

Statistical analyses

We applied a machine learning - based approach, in which the aim was to maximize prediction performance. We used logistic regression as the basic model structure, explaining 'interest' probability with a subset of the potential predictors. The final logistic regression model was of the form

$$\Lambda^{-1}(\pi) = log_e \frac{\pi}{1-\pi} = logit(\pi) = \beta^T x \quad (1)$$

where y, x, and β denote 'interest', final predictors, and the corresponding model parameters, respectively. $E(y \mid x) = \pi$ and $\Lambda(z) = 1/(1+e^{(-z)})$ denote the cdf of the logistic distribution. Model selection was performed by constructing each possible predictor combination from the potential predictor set. For each predictor combination, 10-fold cross-validation (CV) was performed. For each fold, a model was fitted, and a performance metric was calculated. We chose accuracy as the performance metric, which is the overall proportion of correct predictions. For each predictor combination, a single CV accuracy measure was obtained by taking the mean of the 10 cross-validation accuracy measures. Finally, the predictor set corresponding to the maximum CV accuracy was chosen as the final predictor set. The whole CV model selection process was executed using three different threshold probabilities for predicting the 'interest' class.

The final predictor set's accuracy was compared to the no information rate, which is the larger proportion of the 'interest' dummy response. For the model to have any merit as a predictive model, its accuracy must exceed the no information rate. Otherwise, better predictive results are obtained by always simply predicting a single response class. For each predictor in the final predictor set, we calculated a variable importance metric by considering each predictor as the sole predictor and calculating the concordance index (c index). Finally, we constructed a simulated dataset of fixed predictor values to compare the response probabilities between work ability categories.

There was class imbalance between the response classes, as seen in Table 1. To tackle the issue, we applied upsampling of the minority class to match the class frequencies. This was done to investigate whether the model could better learn the minority class and not let the majority class dominate and introduce possible bias. The results were compared mainly using the receiver operating characteristic (ROC) curve and the area under the ROC curve (AUC). ROC is a graphical plot that measures the performance of a binary classifier at varying thresholds, and AUC is a metric constructed from the ROC curve.

Statistical modeling was performed using the R software (R Core Team 2023) and packages caret (Kuhn, 2008), dplyr (Wickham et al., 2023), ggplot2 (Wickham, 2016), and Metrics (Hamner & Frasco, 2018).

Research ethics

This study was conducted by Natural Resources Institute Finland (Luke), a government research institute for agriculture, forestry, and fishing (Finlex, 2014), which is committed to complying with the ethical principles of the Finnish National Board on Research Integrity TENK (Finnish National Board on Research Integrity TENK, 2012).

RESULTS

The cross-validation (CV) model selection process was performed using 0.50, 0.35, and 0.20 as the threshold probabilities. If the observation's prediction probability exceeds the threshold value, it receives the prediction class Yes. The threshold value can be modified to adjust for false positive and false negative rates. Table 5 shows best model predictor sets, accuracies, false positive rates, false negative rates, and the proportion of No class predictions for each threshold probability. For each threshold value, the model accuracy exceeds the no information rate. However, the margin is only small. The overall predictive merit of the models is therefore modest. This is at least partly because the response variable is imbalanced. When the threshold decreases, accuracy decreases, the false positive rate increases, and the false negative rate decreases. All in all, the false negative rate is large. This is because the total frequency of the Yes class is small. Most of the true Yes class observations are wrongly predicted to be No class. Our main priority was to maximize accuracy, and we did not have strict requirements for false positive or false negative rates. We therefore chose the threshold probability 0.5 and the corresponding predictor set as our final predictors.

Table 5. Model accuracy and no information rate

	Threshold 0.5	Threshold 0.35	Threshold 0.20
Predictors	work ability, main production sector, age, farm succession, organic agreement, other business, developing crop farming	work ability, profitability, indebtedness, training, farm succession, organic agreement	work ability, organic agreement
CV accuracy	83.9%	83.5%	83.2%
False positive rate	0.7%	1.5%	2.0%
False negative rate	91.6%	89.8%	89.2%
Proportion of No class predictions	98%	97.0%	96.5%
No information rate	83%		

Upsampling with replacement to investigate the possible domination of the majority class was used. After upsampling, the minority class frequency was increased from 501 to 2,447 to match the majority class frequency. The ROC curves for both the original and the upsampled datasets were calculated (Figs A1 and A2 in the Appendix, respectively). The ROC curves are practically identical. The x-axis (Specificity) measures the true negative rate, whereas the y-axis (Sensitivity) measures the true positive rate. There is a trade-off between sensitivity and specificity - when one increases, the other decreases, and vice versa. Thus, it is ultimately the decision of the applier of the classifier where they want to fix the threshold. The ROC curve shows that for whatever threshold for the original dataset classifier, there is a threshold for the upsampled datasets classifier for which the sensitivity and specificity pair gives equal values. The AUC values for the original and upsampled datasets were 0.681 and 685, respectively. Thus, both classifiers perform in the range of poor to fair. It is also concluded that upsampling did not provide a significant increase in performance. This might be due to lack of diversity of the original data, limitations of the classifier or data quality. Authors did not tackle any of these issues in this paper.

Table 6. Predictive variables for interest in switching to organic production in the final model. The total number of persons N = 2,948

	Frequencies (relative)	Min, max, mean, median	Model coefficient	OR (95% CI)	c-index
Work ability		-			0.52
Good	1,582 (0.54)		baseline		
Declined	1,366 (0.46)		0.44	1.56 (1.26, 1.92)	
Main production sector		-			0.54
Cereal crops	991 (0.34)		baseline		
Horticulture and special plants	338 (0.11)		-0.59	0.55 (0.38, 0.80)	
Other plants	336 (0.11)		0.03	1.02 (0.70, 1.50)	
Animals	1,283 (0.44)		-0.03	0.97 (0.77, 1.23)	
Age		-			0.58
<35	215 (0.07)		baseline		
35–44	542 (0.18)		-0.23	0.79 (0.54, 1.17)	
45–54	975 (0.33)		-0.40	0.69 (0.47, 1.01)	
55+	1,216 (0.41)		-0.67	0.51 (0.34, 0.76)	
Farm succession		-			0.60
No	877 (0.3)		baseline		
Yes, certainly	299 (0.1)		0.26	1.30 (0.85, 1.99)	
Yes, possibly	892 (0.3)		0.84	2.32 (1.74, 3.11)	
Not currently relevant	880 (0.3)		0.72	2.05 (1.51, 2.80)	
Organic agreement		-			0.54
No	2,845 (0.97)		baseline		
Yes	103 (0.03)		1.74	5.70 (3.72, 8.73)	
Other business		-			0.55
No	1,493 (0.51)		baseline		
Yes	1,455 (0.49)		0.31	1.36 (1.11, 1.68)	
Developing crop farming	-	2.0, 45.0, 19.9, 19.0	-0.04	0.96 (0.95, 0.98)	0.56

Table 6 shows information regarding the response and predictors. The total number of observations in the final data was 2,948. The point estimate odds ratio (OR) for work ability is 1.56 (Confidence interval, CI, 1.26, 1.92), i.e. those with diminished work ability had a higher probability of interest in switching to organic production. Horticulture production as the main production sector had a significant negative effect on interest, as did the farmer's age of 55 years or over. The answers 'Yes, possibly' and 'Not currently relevant' to the question concerning farm successor had a significant positive effect. Already having part of the farm in organic production was a strong predictor for switching also other parts to organic production. Having another business activity in addition to basic agriculture had a significant positive effect. Developing crop farming practices had a slightly but significantly, negative effect.

Table 7. Examples of the estimated probabilities (and confidence intervals) for 'interest' = yes

Work ability	Main production sector	Age	Farm succession (mode)	Organic agreement (mode)	Other business	Cultivation development (median)	Estimated probability of 'interest' = Yes
Diminished	Cereal crop production	35–44	4	No	Yes	18	0.305 (0.236–0.374)
Good	Cereal crop production	35–44	4	No	No	17	0.117 (0.131–0.223)
Diminished	Horticulture and special plants	35–44	4	No	Yes	18	0.195 (0.126–0.264)
Good	Horticulture and special plants	35–44	4	No	Yes	14.5	0.151 (0.097–0.205)
Diminished	Animal production	35–44	4	No	Yes	19	0.291 (0.223–0.359)
Good	Animal production	35–44	4	No	No	19	0.162 (0.122–0.202)
Diminished	Cereal crop production	55+	4	No	Yes	19	0.214 (0.159–0.270)
Good	Cereal crop production	55+	3	No	No	18	0.061 (0.041–0.081)
Diminished	Horticulture and special plants	55+	3	No	Yes	20	0.066 (0.039–0.093)
Good	Horticulture and special plants	55+	2	No	Yes	16	0.109 (0.068–0.150)
Diminished	Animal production	55+	3	No	No	20	0.084 (0.059–0.108)
Good	Animal production	55+	3	No	No	19	0.057 (0.038–0.076)

Table 7 shows some examples of the estimated probabilities with 95% confidence intervals for the interest in switching to organic production ('yes' class for interest). For example, when the cereal crop producer is between the ages of 35 and 44, the probability of choosing 'yes' is higher if the farmer has diminished work ability and other business in addition to basic agriculture (class 'yes') than if the farmer has good work ability and no other businesses (keeping successor issues and organic agreement in the mode class and developing crop farming in the median). The 95% confidence intervals do not overlap, which gives some indication of a significant difference between these probabilities. The same trend arises among animal producers of the same age group and among cereal producers in the older age group (55+).

DISCUSSION

Overall, 17% of farmers reported an interest in switching to practicing organic production, which is promising when considering the national goal for organic production. The challenge is that based on the results, farmers' diminished work ability was associated with an interest in switching from conventional to organic production. Based on the work ability theory (Gould et al., 2008), these findings suggest that an imbalance between work demands and farmers' personal resources is more frequent on farms interested in switching from conventional to organic production. The reasons behind this imbalance can be several. Diagnosed diseases, physically hard work, mental workload, lack of recovery from work, older age, economic uncertainties, and small farm size have been noted to be associated with declined work ability of farmers (Karttunen & Rautiainen, 2011; Mattila et al., 2020). Farmers may see organic farming as an interesting option, which could produce financial or well-being benefits that may improve their overall life situation. What actually happens to farmers' work ability after the transition to organic farming cannot be discerned from this study. However, the findings of previous studies (Mattila et al., 2020) have linked declined work ability with organic production, which suggests that switching to organic farming does not necessarily improve work ability of farmers. It should be noted that work ability explores the work system, particularly the balance between farmer's skills, motivation, and other resources in the relation to the demands at work. This is only one perspective to the well-being of farmers. E.g. Mzoughi (2014) has found that organic farming may have a positive impact on life satisfaction, and Cross et al. (2008) found some indication that workers on organic farms may be happier. Even if organic farming is challenging in many ways and requires new professional skills, there may also be positive health effects unique to organic farming (Brigance et al., 2018).

Well-being at work and the success of the farm business are intertwined. For example, mentally distressed farmers may perceive their financial situation worse than it actually is, which easily leads to unwillingness to invest and develop farming. In the long run this can lead to financial challenges and declining of their farm business (Gorgievski et al., 2010; Gorgievski & Ute 2016). Dijkhuizen et al. (2018) stated that entrepreneurs' well-being is a key factor in the long-term business outcomes (achieved subjective financial and personal success) and should be carefully maintained and improved. It is alarming that declined work ability is so frequent among farmers. It may have an effect also on their ability to achieve goals they have set for the switching process.

Based on this study, farmers who already had a part of their farm in organic production, and farmers who had another business activity in addition to basic agriculture, were more interested in expanding or converting to organic production. These findings are in accordance with earlier studies where other income sources or having diversified production predicted the interest in switching to organic production (Kallas et al., 2010; Mattila et al., 2018). Diversifying farm activities reduces risks (Kallas et al., 2010), and organic producers benefit particularly from specific direct sales channels (Rikkonen et al., 2017).

Production of horticulture or special crops as the main product and an older age (55+) had a negative effect on the interest in switching from conventional to organic production in the analysis. This result corresponds to the earlier findings among Finnish horticulture farms, only 12.1% were interested in switching to organic production; the interest was greater among smaller part-time enterprises (Mattila et al., 2018). Similarly, some previous studies have also found a younger age to be associated with the adoption of organic production (Burton et al., 1999; Kallas et al., 2010), but not necessarily in all farming sectors (Mattila et al., 2018). Moreover, organic farming tends to attract new entrants into the farming sector (e.g., Kallas et al., 2010; Väre et al., 2021; Farrell et al., 2022).

In this study, it was also found that farm succession planning was associated with switching to organic production; the likelihood of switching was more than doubled if the question about having an identified successor for the farm was answered as 'yes, possibly'. However, also situation where succession is 'not currently relevant' was associated with interest to switch to organic production. Plans for developing (conventional) crop farming practices had a slightly negative effect on the interest in switching. It should be noted that developing crop farming methods is very important also in organic production (like crop rotation), but by far, most of the organic farmland in Finland is used for cultivated grass production (Koivisto et al., 2020).

Between 2010 and 2020, 2,792 operators started and 1,661 gave up organic production (Finnish Food Authority, 2021). The reasons for exiting have not been analyzed, but the overall reduction in the number of farms is one reason, i.e., farmers do not necessarily revert to practicing conventional farming but retire or give up farming for other reasons. The potential role of declining work ability would be of specific interest in future studies. In Norway, Koesling et al. (2012) have studied the reasons for deregistering from organic production where farmers' decisions were influenced by financial issues, attitudes of the surrounding community, attraction of work outside farming, lack of information and communication about the benefits of organic production, and weaknesses in the implementation of regulatory changes. Gambelli & Brushi (2010) found that vegetable farms in particular had a high probability of exiting from organic farming due to technical and agronomical difficulties and difficulties in processing, distributing and marketing. They also found that farmers' age, farm location, and farm size influenced the probability of continuing organic farming. Organizing work during the transition process has been observed as a particular challenge. This may cause severe stress to farmers and make it challenging to meet the goals that they have set for the change (Navarrete et al., 2015; Chizallet et al., 2018; Väre et al., 2021). The transition period can be financially difficult, requiring an ability to learn and adopt new modes of operation (Koesling et al., 2004; Sipiläinen & Lansink 2005; Koesling et al., 2012; Navarrete et al., 2015; Chizallet et al., 2018).

Limitations

The final model's predictive power was not strong. This may be due to the underlying difficulty to capture the effect as there may be large natural variation. It is also possible that the class imbalance means more data is needed to increase the prediction performance. In Finland, the numbers of current organic farms are quite low, as are the numbers of those who are interested in switching to organic production, and thus the possibilities to obtain larger datasets are limited. Moreover, the definition of organic farm is not clear in all situations, which in our case resulted in excluding some farms from analyses.

The cross-sectional data offers a possibility to explore associations between variables, but not their causal relationships. This limitation must be kept in mind when interpreting the findings.

CONCLUSIONS

Declining work ability is common among farmers, and it predicts farmers' willingness to switch to organic production. Reasons behind declined work ability can be several, e.g. physical and mental workload, lack of recovery, older age, disabling diseases, and economic uncertainties. Measures to protect the health and well-being are critically important for long term business success, and health and safety should be integral parts of the switching process. Earlier studies suggest that organic farming requires even more skills in various areas, thus exposing farmers to more stress compared to conventional farming. Organising work and managing the workload are critical preventive measures on both conventional and organic farms, and they should be supported by advisory services. The need for such support should be further explored in future studies for farms with different development phases, capabilities, and goals, including the farmers' work ability limitations. In addition to ecological sustainability, principles of organic production also include social sustainability. In order to achieve future goals of increasing the share of organic production, social sustainability and the farmers' work ability must be considered.

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APPENDIX

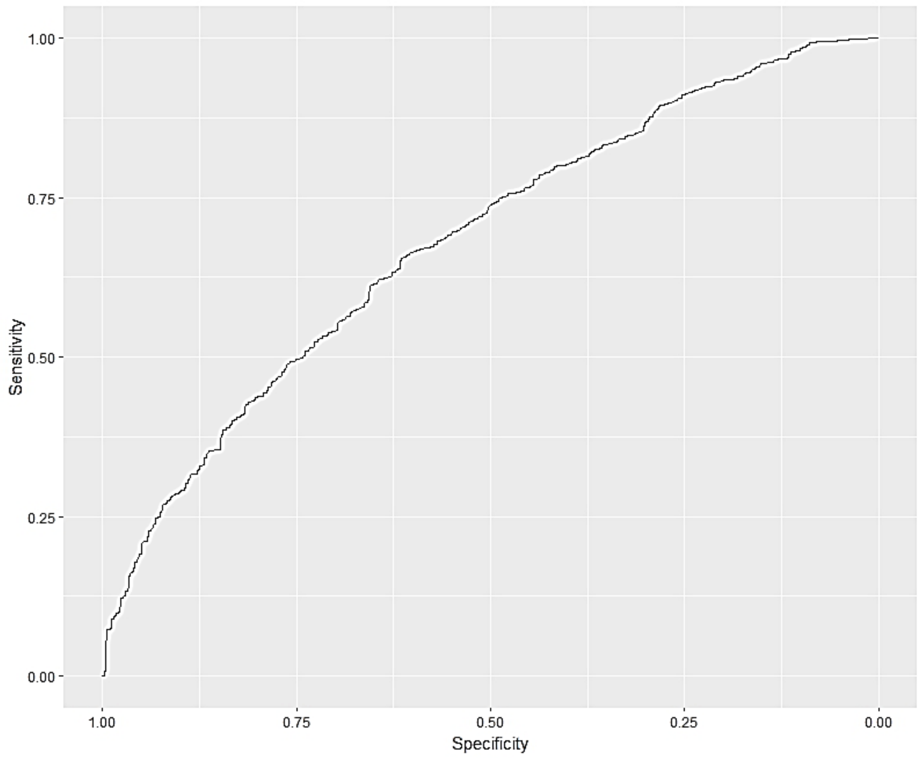

Figure A1. ROC curve showing the performance of the classifier based on the original dataset.

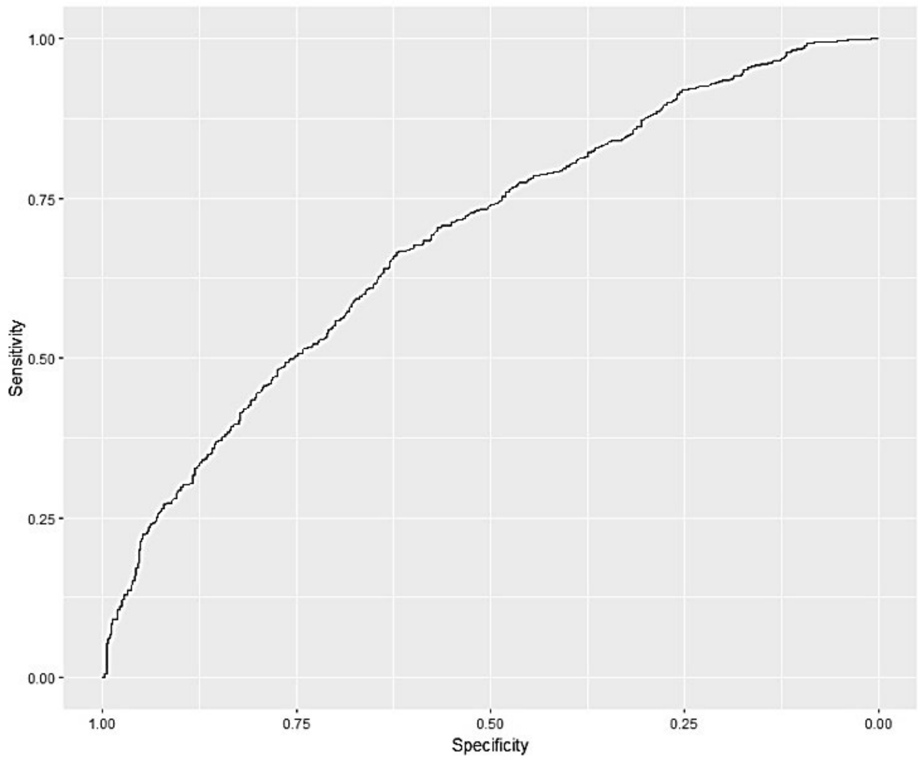

Figure A2. ROC curve showing the performance of the classifier based on the upsampled dataset.