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Market power, profitability and the decision to exit organic dairy farming in the EU

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Abstract

Organic agriculture is a widely established production system that contributes to various sustainability goals. The European Commission has set the goal of 25% organic agriculture in 2030 in its Farm to Fork strategy, putting it further in the spotlight. However, in most European countries, progress towards this goal is still limited, and some farmers even move back to conventional production. The further expansion of organic farming will crucially depend on the development of organic markets and its financial competitiveness. However, evidence on the economic performance of organic farmers in the EU and the decision to revert back to conventional production is lacking. We analyze the causal effect of dairy farmers' decision to produce organically on farm competitiveness measured by price markups and profitability. Moreover, we investigate the decision of organic farmers to revert back to conventional farming using survivorship analysis. Our results reveal that organic farms achieve higher markups and profitability. But, there is a high probability of exiting the organic market in the early phase after transition - especially for farms with highly volatile economic performance. The results provide insights that may help to reach the political targets with regards to the market share of organic agriculture.

JEL Codes: D22, L11, L66, Q12, Q18

1. Introduction

Organic markets have experienced a steep incline during the past decades. For example, the share of organic land has increased by 66 percent from 2009 to 2019 and accounts for 9.9 percent of the total agricultural land in the European Union (EU) in 2021 (European Commission, 2021; European Commission, 2023; Eurostat, 2023). Organic agriculture presents an innovative and widely established production system that can contribute to various sustainability goals. For this reason, the European Commission has recently set a target of 25 percent organic agriculture by 2030 in its "From Farm to Fork" strategy. This is particularly relevant because food systems make a significant contribution to global greenhouse gas emissions (Crowder and Reganold 2015; De Schutter, 2014; European Commission, 2021). In addition, animal welfare concerns and the refusal to apply synthetic pesticides and fertilizers have made the support of organic agriculture a top priority on the policy agenda, for example, in the United States (USDA 2019) and the EU (European Commission 2023). However, in most European countries, progress towards the 25 percent goal is still limited, and some farmers are even moving back out of organic production. The further expansion of organic farming will crucially depend on the development of organic markets and its financial competitiveness compared to conventional farming (Crowder and Reganold 2015). Nevertheless, research on the competitiveness of organic farmers in the EU and the decision to revert back to conventional production is lacking.

We analyze the impact of EU dairy farmers' decision to produce organically on their economic performance measured by markups of price over marginal cost and profitability measured by return on assets. We aim to identify the causal effect by accounting for endogeneity in the decision to pursue organic farming. Moreover, we investigate the decision of organic farmers to revert back to conventional farming using survivorship analysis deriving exit probabilities for each year after conversion to organic farming. We also assess which farm- and market specific characteristics are related with a higher exit probability.

Besides its benefits with regards to sustainability, organic farming can generate price premia as it enables dairy farmers to countervail processors and retailers' bargaining power (Crowder and Reganold 2015). This is important given the evidence for farmers' exposure to downstream market power reducing farm income (Sexton and Xia 2018). Nevertheless, organic production is also associated with higher costs of production raising the question whether organic farmers have an improved bargaining position and superior financial performance compared with conventional farmers (Koppenberg, 2023). Several studies have investigated differences in the profitability of organic and conventional farming (e.g., Uematsu and Mishra 2012; Khanal et al. 2018; Froehlich et al. 2018; Clark 2009; Grovermann et al., 2021)[1]. However, those studies mainly focus on smaller sets of firms, or developing countries (e.g., Froehlich et al. 2018; Rattanasuteekarul and Thapa 2012; Bolwig et al., 2009; Tran and Goto, 2019)

[1] See for example Crowder and Reganold (2015) for a systematic review on the differences of financial performance between conventional and organic agriculture.

while holistic evidence for the EU is as yet missing. An exemption is the study by Grovermann et al. (2021) which is probably most closely related to our study. They investigate efficiency and gross margins of European dairy farms over the period 2011-2013 accounting for the endogeneity in the organic certification decision. However, they do not consider markups as an important performance measure given farmers inferior position in the value chain. Koppenberg (2023) provides a first attempt to measure differences in the market power of organic and conventional farming and finds that the latter generate a markup premium of up to 258%-points. However, the study does not investigate the profitability of organic farms and does not account for endogeneity in the decision to produce organically. Particularly, reversion back to conventional farming has become an important topic in the literature, as recently there has been an increasing trend of withdrawal from organic production (e.g., Heinze and Vogel 2017; Madelrieux and Alavoine-Mornas 2013; Sahm et al., 2013). Heinze and Vogel (2017) find that 30 percent of German farms that started to produce organically between 1999 and 2003 had reverted back by 2010. For the U.S. Brady et al. (2023) investigate exit decisions of organic farms in Washington State and find that organic farms have the highest likelihood of exiting two years after transition. Moreover, Marton and Storm (2021) show that exit of organic dairy farms in Norway can have negative spillover effects on organic conversion of neigbouring farms.

We extend this literature by i) investigating the effect of organic production on dairy farms' market power (markups) and financial performance (profitability) using an extended regression framework that allows us to address endogeneity in the organic production decision. Our aim is to provide a holistic picture of the competitiveness of organic dairy farming in the EU. ii) We investigate the role of farm size and other farm-specific characteristics for the competitiveness of organic farming. iii) We apply survivorship analysis to determine probabilities of exiting the organic market for each year after transition. Moreover, we relate the exit decision to several farm characteristics such as farm size and volatility in economic performance as well as market characteristics such as the organic price premium and concentration in food retailing. To our knowledge, this is the first attempt to provide a holistic view of the economic viability of organic farming in the EU.

We use a panel data set with detailed financial information of approximately 40,000 European dairy farms with more than 190,000 observations that is provided by the European Farm Accountancy Data Network (FADN). The FADN panel spans all member states of the EU and the United Kingdom in the years 2004-2017. Our study focuses on the European dairy farming sector since dairy farmers have accused downstream companies i.e., dairy processors and food retailers to abuse market power in several instances (Grau and Hockmann, 2018). Also, dairy farming plays an important role in the organic sector given its significant environmental impact and increasing relevance of animal welfare (Rosati and Aumaitre, 2004). Consequently, European dairy farming presents an interesting case to examine differences in the economic performance of organic and conventional agriculture.

Our results are of relevance for policy makers to design targeted support schemes for farmers adoption of organic practices and their persistent performance in the market. Understanding the competitiveness of organic dairy farmers and their behavior after the transition to organic production may allow policymakers to derive tailored measures that support the persistence of organic farms. Our insights in farmers' decision to exit organic farming enables policy makers to identify the appropriate timing for financial farm support and implement measures to prevent the exit. Thus, our results provide evidence that may help to reach the political targets with regards to the market share of organic agriculture.

The article is structured as follows. In section 3 the empirical approach, including the derivation of farm markups, the estimation of the effect of organic farming including the identification strategy and the analysis of withdrawal from organic production are described. Section 4 provides information on the dataset used, while in Section 5 the results and robustness checks are discussed. Section 6 presents some conclusions.

2. Empirical framework

3.1 Measuring Markups

While farm profits are directly observable from the dataset, we need to derive a measure for markups. In the context of output markets operating under conditions of perfect competition, the pricing (P) of a product aligns with its marginal cost (MC). A measure commonly used to assess deviations from competitive pricing is a firm's markup (μ) (Koppenberg 2023). The markup (μ) is derived by dividing the price (P) by the marginal cost (MC) (Autor et al. 2020; De Loecker et al. 2020). A markup value of 1 signifies a state of perfect competition, while values above 1 indicate the potential existence of monopolistic or oligopolistic market power held by the farmers.

There exist several methods of estimating markups, but not all of them are suitable for the objective of this study. One such method is the production function approach by De Loecker and Warzynski (2012) which is based on a single production function to estimate μ. However, this approach proves unsuitable for the present case as it fails to account for the interrelationships among different outputs in agriculture which are jointly produced in the same processes (Hall 1973; Lence and Miller 1998). Another method is the stochastic frontier approach developed by Kumbhakar et al. (2012) which assumes markups to be larger or equal to one. However, this does not neccesarily hold true for our analysis, since farmers may continue operating their business even with a markup below one because of subsidies received (Koppenberg and Hirsch 2022; Koppenberg 2023).

For this study, we follow Koppenberg (2023) and use a cost function approach to estimate μ.[2] Here, it is assumed that dairy farmers minimize costs by considering milk output quantities as given and non-adjustable (Wieck and Heckelei 2007). This restriction in milk output is due to the milk quota that was

[2] More specifically, our aim in this approach is to estimate *MC* while our dataset contains information about *P*.

imposed by the EU from 1984-2015. To achieve cost minimization, variable input quantities are selected for given output levels alongside quasi-fixed inputs to ensure cost optimization. The short-run variable cost function (C) for farmer i is defined as:

$$C_i = W'X + R'K \; s.t. \; f(X,K) = Q \qquad (1)$$

In this context, we denote **W** as a vector encompassing prices of variable inputs, while **X** represents the vector of quantities of these inputs. **R** and **K** refer to price and quantity vectors of quasi-fixed factors, respectively. Quasi-fixed factors are not adjustable in the short run, meaning that farmers minimize costs while taking the quantities of **K** into consideration. **Q** represents a vector of output quantities. The transformation of inputs into outputs is captured by the function $f(.)$. The cost function exhibits a non-decreasing relationship with **Q** and **W**, and it is linearly homogeneous with respect to **W** (Coelli et al., 2005). Furthermore, C demonstrates concavity with respect to each element of **W**, implying that for a given relative increase in some **W**, costs will rise to a lesser extent due to the substitutability of inputs. The cost minimization problem can be formulated using the Lagrangian (L).

$$L = W'X + R'K - \lambda(f(X,K) - Q) \qquad (2)$$

The Lagrange multiplier λ is utilized in the optimization problem. By taking the first derivatives with respect to **X** and λ, and equating them to zero, the first-order conditions (FOC) of the problem are obtained. By solving this system of equations, the contingent input demand functions can be derived. Substituting these functions into Equation (1) allows us to derive the minimum cost function C(**Q**, **W**, **K**) for farmers in the short run. This cost function is the main target for estimation.

Due to its flexibility, we use a translog functional form of the cost function to approximate the true cost function which is defined as follows:

$$\begin{aligned} lnC = {} & \kappa_0 + \sum_{l=1}^{L} \alpha_l lnQ_l + 0.5 \sum_{l=1}^{L} \sum_{m=1}^{M} \alpha_{lm} lnQ_l lnQ_m + \sum_{j=1}^{J} \beta_j lnW_j + \\ & 0.5 \sum_{j=1}^{J} \sum_{k=1}^{K} \beta_{jk} lnW_j lnW_k + \sum_{l=1}^{L} \sum_{j=1}^{J} \gamma_{lj} lnQ_l lnW_j + \sum_{r=1}^{R} \upsilon_r lnK_r + \\ & 0.5 \sum_{r=1}^{R} \sum_{s=1}^{S} \upsilon_{rs} lnK_r lnK_s + \sum_{l=1}^{L} \sum_{r=1}^{R} \eta_{lr} lnQ_l lnK_r + \sum_{j=1}^{J} \sum_{r=1}^{R} \omega_{lr} lnW_j lnK_r + \\ & \sum_{t=1}^{T} \delta_t Tech_t + \varepsilon \end{aligned} \qquad (3)$$

C is the farmers' short-run variable cost. Q, W and K denote output quantities of outputs L (M), input prices of the J (K) variable inputs and quantities of the R (S) quasi-fixed inputs. $\alpha, \beta, \gamma, \delta, \upsilon, \eta, \omega$ and κ_0 represent the parameters to be estimated. We define outputs, quasi-fixed and variables inputs following previous literature (De Frahan et al. 2011; Renner et al. 2014; Skevas et al. 2018; Wieck and Heckelei 2007; Wimmer and Sauer 2020). In particular, the outputs are (1) milk, (2) meat and (3) crop output other than feedstuff[3]. The variable inputs are (1) purchased feed, (2) energy and (3) seeds, fertilizer and

[3] An aggregation into one single output is not feasible in the present case as we are particularly interested in the markups for milk production. Hence, using a compound output measure would lead to an overall markup across

plant protection products. Last, the quasi-fixed inputs comprise (1) unpaid labor[4], (2) paid labor, (3) land, (4) capital and (5) dairy cows and (6) other livestock.

Equation (1) is symmetric so that $\alpha_{lm} = \alpha_{ml}$, $\beta_{jk} = \beta_{kj}$ and $\upsilon_{rs} = \upsilon_{sr}$ for all l, m, j, k, r and s (Coelli et al. 2005). The cost function is monotonically increasing in outputs and variable input prices as well as linearly homogeneous and concave in variable input prices. Linear homogeneity of the cost function requires the following parametric restrictions in (1): $\sum_{j=1}^{J} \beta_j = 1, \sum_{k=1}^{K} \beta_{jk} = \sum_{l=1}^{L} \gamma_{lj} = \sum_{r=1}^{R} \omega_{jr} = 0$ (Alem et al. 2019; Liu et al. 2014; Ray 1982). We cannot impose monotonicity in outputs and variable input prices as well as concavity in variable input prices a priori. We therefore test them a posteriori. C will monotonically increase in outputs, if the partial first derivatives of C with respect to all outputs and variable input prices are non-negative. C will be concave in variable inputs prices, if the Hessian of second derivatives with respect to the variable input prices is negative semi definite (Diewert and Wales 1987).[5] After testing the regularity conditions, we exclude all observations from further analysis which do not fulfill the conditions (Koppenberg and Hirsch 2022; Salvanes and Tjøtta 1998).

We address problems caused by the occurrence of zero values for the variables in (1) using the procedure proposed by Battese (1997) which is well established in applied research (e.g., Rasmussen 2010; Renner et al. 2014; Villano et al. 2015; Wimmer and Sauer 2020). We introduce a dummy variable for each variable in (1) which will be equal to one, if the corresponding variable equals zero, and equal to zero, if the corresponding variable is larger than zero. The value of the original variable is replaced by a value of one, if the original value was zero. Note that we also test for different technologies between conventional and organic dairy farms, and specialized dairy farms and mixed farms (also producing crops). We refer the reader to the Appendix for details on the test procedure.

After estimating (3), we take its first derivative with respect to log milk output (lnQ_1). We multiply this derivative by the ratio of total variable cost (C) over milk output (Q_1) to obtain an estimate of MC:

$$MC = \frac{\partial C}{\partial Q_1} = \frac{\partial lnC}{\partial lnQ_1}\frac{C}{Q_1} = \Big(\alpha_1 + 0.5 \sum_{m=1}^{M} \alpha_{1m} lnQ_m + \sum_{j=1}^{J} \gamma_{1j} lnW_j + \sum_{r=1}^{R} \eta_{1r} lnK_r\Big)\frac{C}{Q_1} \tag{4}$$

We can then estimate markups (μ) as the ratio of output prices over the estimate of MC, i.e., $\hat{\mu} = P/\widehat{MC}$.

2.2 Effect of organic farming on markups and profits

We estimate several models to test if the economic performance measured by markups and profitability

all outputs, i.e., milk, meat and crops which would impede us from generating separate markups for each output (Mosheim and Knox Lovell 2009).

[4] If unpaid labor was considered as a variable input, we would have to assign a shadow price to it.
[5] This will be fulfilled, if all Eigenvalues of the Hessian are non-positive (Morey 1986).

differs between conventional and organic producers.

$$Perf_{j,i,t} = \alpha + \beta Org_{i,t} + \sum_{k} \alpha_k X_{k,i,t} + \gamma_C + \tau_t + \varepsilon_{i,t} \quad (5)$$

The dependend variable in (5) is the economic performance of farm *i* in year *t* measured by the $j = 1, 2$ indicators markups ($\hat{\mu}_{i,t}$) and profitability ($\pi_{i,t}$) measured by return on assets (ROA), respectively. $Org_{i,t}$ is a dummy variable that captures whether a farm *i* is organic (*Org*) in year *t*. The vector $X_{k,i,t}$ reflects a set of k control variables including farm size, unpaid labor hours, stocking density, deviation from optimal input usage of seeds, pesticides and fertilizers and the share of farms' fixed costs. The latter is calculated by subtracting all costs for variable inputs as indicated in (3) from total costs. This allows us to assess whether markups are indeed associated with market power or used to cover fixed costs (De Loecker et al. 2020). Moreover, we control for the shares of medium and large processing firms and retailers in the country the farm operates. Finally, we include country and year fixed-effects reflected by γ_C and τ_t, respectively while $\varepsilon_{i,t}$ is an i.i.d. error term.

For the estimation of equations 3 and 4 we use an extended maximum likelihood regression approach (Stata Press, 2019) that allows us to consider potential endogeneity in the binary production type variable (*Org*). The extended regression approach is based on a probit model in the first-stage to account for the binary endogenous variables of interest. The model parameters are estimated using a maximum likelihood approach. Conditional on the set of exogenous variables, the approach derives parameters for the joint distribution of the endogenous dummy variable (*Org*) and the dependent variable ($\hat{\mu}_{i,t}$ or $\pi_{i,t}$).

We use the lags of the price differential between conventional and organic milk on the national level (organic price premium) and the market share of organic milk as instruments. Those instruments are expected to drive the decision between organic and conventional production but are only related to markups and profitability through the production type decision. Lal et al. (2021) provides a checklist to evaluate the validity of the instruments that we closely follow. This includes assessment on whether the exclusion restrictions are violated and tests of overidentification. In addition, we use the correlation between the error terms of the main equations and their respective first-stage equations to investigate whether the independent variable of interest (*Org*) is endogenous at all. The underlying null hypothesis of "no endogeneity in the organic management decisions" can be rejected if the correlation is statistically significant, which indicates the need of an IV approach.

Furthermore, we estimate (5) using the limited information maximum likelihood (LIML) estimator as a robustness check. Although this estimator does not account for the binary nature of the *Org* variable, its advantage is the availability of tests for instrument strength and overidentification, which are not available for the extended maximum likelihood estimator. We use the LIML estimator instead of classical two-stage least squares (2SLS) because Keane and Neal (2023) show that 2SLS estimation is biased towards OLS when the model is overidentified, as is the case in our analysis.

2.3. Reversion back to conventional farming

We are interested in how far the probability of exiting the organic market (*Exit*) i.e., switching back to conventional production changes over time and in how far it is related to farm specific characteristics. We analyze these issues using survivorship analysis applied to the sample of organic dairy farms.

We first follow Brady et al. (2023) and implement the survivorship analysis by estimating a discrete-time random-effects complementary log–log (cloglog) hazard model to determine for each year after entry the probability that farms exit the organic market (Cameron and Trivedi, 2022). The underlying model is specified as follows:

$$Exit_{i,t} = \alpha + \sum\nolimits_{y} \beta_y \theta_{i,t,y} + \varepsilon_{i,t} \qquad (6)$$

The dependent variable (*Exit*) is a dummy that captures whether a farm *i* has switched back from organic to conventional in t. θ is a set of $y \in \{1, 2, \dots, 14\}$ dummy variables, each of which takes the value 1 if farm i is in the *y-th* year after transition in period *t*. The hazard rate, that is the probability that farms revert back to conventional production in year *y* after transition to organic farming conditional on not having exited before *y* can then be calculated for each *y* by $h_y = 1 - \exp\left(-\exp\left(\widehat{\beta_y}\right)\right)$ (Cameron and Trivedi, 2022; Brady et al., 2023).

Second, we want to better understand which farm- and market-specific factors are associated with the decision to return to conventional farming. Therefore, we estimate the cloglog model including as independent variables a continuous time variable (*t*) capturing the years after transition and the same firm and market characteristics that were used in the organic analysis above to estimate (5) as well as the lagged organic price premium and the organic market share:

$$Exit_{i,t} = \alpha + \gamma t_{i,t} + \sum\nolimits_{k} \beta_k X_{k,i,t} + \varepsilon_{i,t} \qquad (7)$$

Last, we also investigate if the decision to exit the organic market is related to volatility in economic performance. Therefore, for each firm,we calculate the volatility of the two performance measures markups and profitability using the measure proposed by Lee and Van Cayseele (2022):

$$Volatility_i = sd(g_i) = \left[\sum \frac{1}{T-1}\left(g_{it} - \overline{g_i}\right)^2\right]^{0.5} \qquad (8)$$

with $\overline{g_i} = \sum \frac{1}{T} g_{it}$ and $g_{it} = ln\left(\frac{\mu_{i,t}}{\mu_{i,t-1}}\right)$ or $g_{it} = ln\left(\frac{\pi_{i,t}}{\pi_{i,t-1}}\right)$

Thus, volatility is calculated as the deviation of yearly changes in markups (profitability) in relation to mean growth over time (e.g., Lee and Van Cayseele 2022, Pieters and Swinnen 2016). Note that only a single volatility measure can be derived for the time series of markups and profitability of each farm. Therefore, we need to reduce our dataset to a cross-section with mean values over *t* for the remaining independent variables ($\bar{X}_{k,i}$). The dependent variable *Exit* reduces to a simple dummy variable with a value of 1 if farm *i* is an exiter in the general sense, i.e., returned to convential farming in any year of the observation period.

$$Exit_i = \alpha + \sigma Volatility_i + \sum_k \beta_k \bar{X}_{k,i} + \varepsilon_{i,} \quad (9)$$

We use equation (9) to identify the effect of volatility of markups and profitability on the probability to exit organic farming.

3. Data

3.1 Derivation of the sample

We use data from the European Farm Accountancy Data Network (FADN). The dataset contains farm-level observations for the years 2004 to 2017 from 24 EU countries (Cyprus, Luxembourg and Malta are missing) and the United Kingdom. The FADN data include information on inputs, outputs and other financial data such as ROA for each farm and year. Besides, we obtain country- and year-specific price indices from Eurostat (2020). The price indices were not available for six countries which we exclude from the analysis: Bulgaria, Croatia, Estonia, Ireland, Lithuania and Romania.

Note that we use price indices for the variable input prices. This is in line with a large body of literature (e.g., Alem et al. 2019; De Frahan et al. 2011; Gullstrand et al. 2013; Wieck and Heckelei 2007). However, it may lead the parameter estimates of the cost function to be biased, if there was unobserved variation in input or output prices between farms (De Loecker et al. 2016; Morlacco 2020). For instance, such variation may be due to differing qualities of inputs, e.g., land, or outputs across farms. As long as the differences are farm-specific and show only small changes in the time dimension, the use of farm-fixed effects/within-differencing eliminates the bias (De Loecker et al. 2016; Jafari et al. 2023). Therefore, we within-difference our data before estimating the cost function for the derivation of markups.

We extract our sample based on the FADN TF14 farming types 45 ("specialist milk"), 49 ("specialist cattle") and 80 ("mixed crops and livestock")[6]. The resulting 39,786 farms producing cows' milk comprise 203,979 observations between 2004 and 2017. 11,378 observations (5.58 percent) stem from organic farms (2,878 farms) and 192,601 (94.42 percent) observations stem from conventional farms (37,761 farms) (2004-2017). 28,106 farmers (115,333 observations) produced milk, meat and crops, i.e., operate mixed farms. 22,079 farmers (88,646 observations) only produced milk and meat, i.e., are specialized in milk production. Table 1 displays the descriptive statistics of all variables. When comparing the sample with the population to evaluate its representativeness (for farming type 45 in

[6] See European Commission (2020) for definitions of all available farming types.

2016) we observe that large farms tend to be overrepresented in eastern European countries whereas they tend to be underrepresented in northern and western European countries.

Table 1: Descriptive Statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Cost function				
Cost [€]	304,658.4	816,013.6	373.0	26,477,742.0
Milk output [kg]	485,785.7	951,719.2	1,000	33,614,380.0
Livestock output [€]	340.8	928.0	<0.1	88,329.8
Crop output [€]	41,655.9	191,346.6	0.0	11,500,880.0
Feed price	108.3	17.7	68.8	146.8
Energy price	100.0	15.6	51.9	141.4
Maintenance of machinery and buildings price	99.7	10.2	71.3	123.3
Crop input price	105.4	18.3	58.2	155.2
Unpaid labor quantity [hours]	3,651.8	1,823.9	0.0	44,896.0
Paid labor quantity [hours]	5,399.0	25,501.1	0.0	1,006,106.0
Land quantity [hectares]	141.4	385.3	0.3	9,997.5
Capital [€]	337,842.3	827,796.6	0.0	24,125,880.0
Dairy cattle quantity [livestock units]	66.7	113.1	<0.1	3,492.3
Farm performance and organic strategy				
Markup (μ)	4.211	4.017	0.000	1,205.089
ROA (π)	0.086	0.107	-1.684	9.940
Organic	0.055		0	1
Exit	0.002		0	1
Control variables				
Ln milk quantity	-1.716	1.568	-6.908	3.515
Fixed costs share (%)	53.444	14.385	0	98.226
Own Labor (100h)	36.501	18.195	0.010	448.960
Stocking density	1.573	2.603	0.014	325.824
Deviation of input use from optimal input use	1.690e-4	0.137	-0.432	0.852
Share medium processors	4.691	3.553	0.244	23.662
Share large processors	26.490	6.291	5.701	57.138
Share medium retailers	9.188	7.811	0.327	66.383
Share large retailers	13.158	7.782	0	22.568
Partnership	0.142		0	1
Family farm	0.785		0	1
Other legal form	0.073		0	1
Instruments				
Organic price premium	0.056	0.080	-0.091	0.630
Organic market share (%)	6.033	4.337	0.500	23.370

Source: European Farm Accountancy Data Network and Eurostat (2020)

3.2 Descriptive analysis

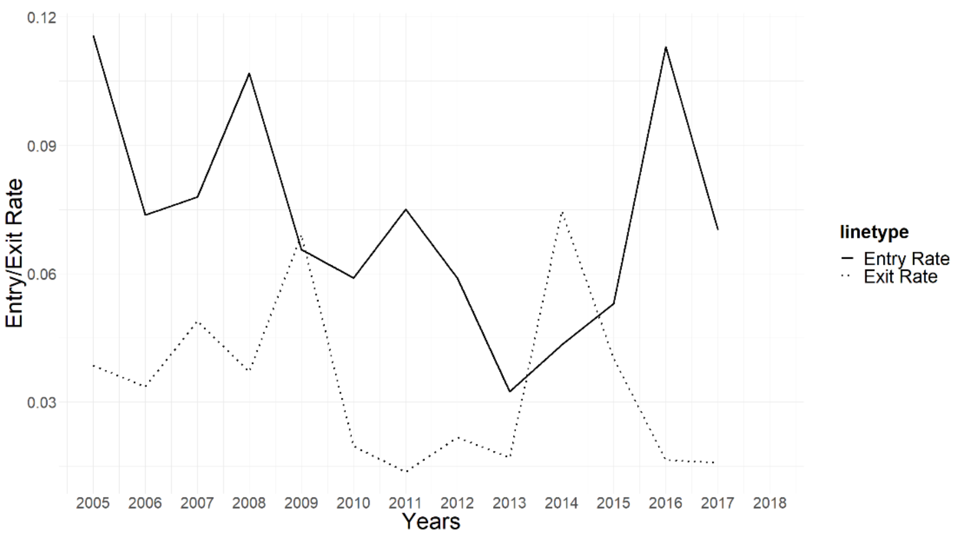
The descriptive comparison between organic and conventional farms in Table 2 reveals that, without controlling for structural farm and market characteristics, organic farms achieve significantly higher markups on average (+1.84). Organic dairy farms also generate significantly higher profits, with ROA exceeding that of conventional farms by 0.4 %-points on average.

Table 2: Comparison of conventional and organic farms

Variable	Organic	Conventional	Difference	t
Markup	5.945	4.109	**1.836*** **	47.301
	(0.047)	(0.009)	(0.039)	
ROA	0.090	0.086	**0.004*** **	4.120
	(0.001)	(2.465e-4)	(0.001)	
Obs.	11,214	191,053		

Notes: Standard errors in parentheses. *** p<0.01

Figure 1 shows the yearly rates of farms entering and exiting the organic market as well as the organic price premium.



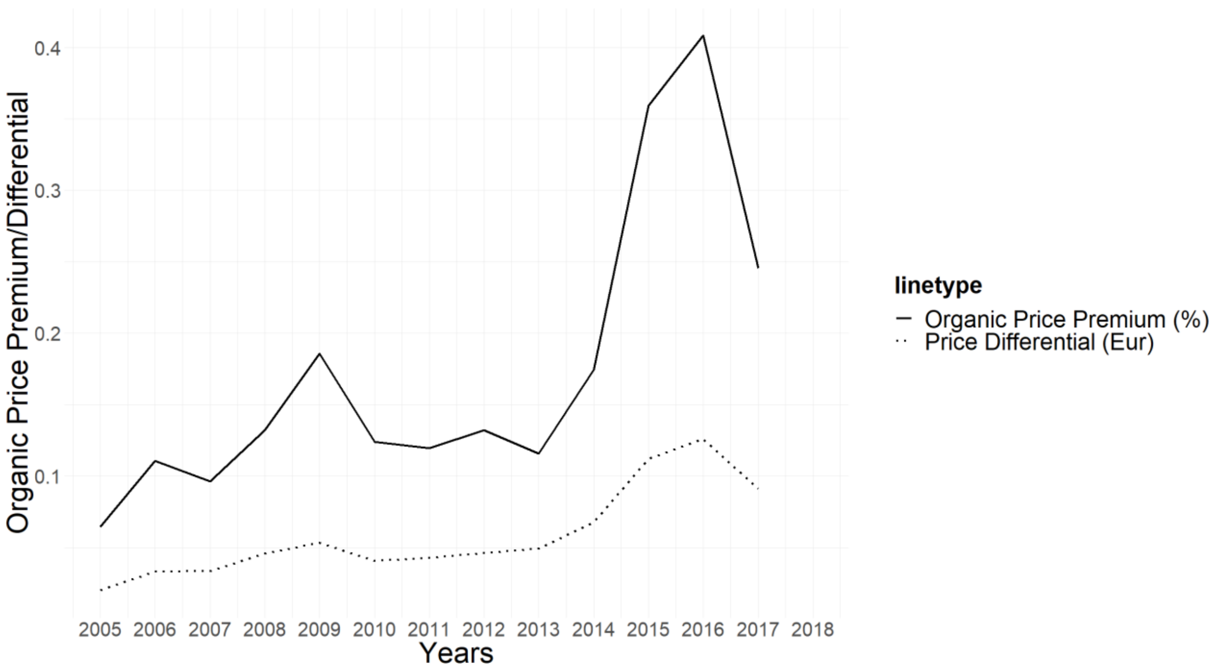


Figure 1: Entry and exit rates and organic price premium (price difference)

4. Results

Results in Table 3 show that organic farms in general generate a markup premium compared to conventional farms. We also detect that the fixed cost share is positively related to markups which indicates that markups are at least partly used to cover fixed costs. In addition, markups and profits are significantly higher for larger farms. Moreover, the presence of large retailers decreases markups and profits. We perform several robustness checks. In column (2) we use FADN region fixed effects instead of country-level fixed effects. In column (3) we exclude the four variables related to the concentration in the food manufacturing and retailing sectors in each country as these variables are only available for a subset of countries which implies that their inclusion reduced the size of our sample. The results in column (3) show that the relationship of organic farming and markups is somewhat lower in this case.[7] In column (4) we exclude all observations from the sample that relate to farms currently in the 2-year transition period from conventional to organic farming to account for high investments during the transition period. However, this does not alter the results. Finally, in column (5) we report the results of estimating the model in column (1) with OLS. It can be observed that this leads to a lower coefficient of the organic dummy variable indicating a downward bias if not considering endogeneity.

[7] Note that in this case we had to remove the upper and bottom 1% of the markup distribution due to issues with convergence with the ML estimator

Table 3. Effect of organic farming on markups

Variable	(1) Country fixed-effects	(2) FADN region fixed-effects	(3) Downstream variables excluded	(4) Without transition	(5) OLS
Lag Markup	0.663***	0.635***	0.446***	0.446***	0.664***
	(0.008)	(0.008)	(0.095)	(0.095)	(0.008)
Org	0.871***	0.940***	0.630***	0.629***	0.710***
	(0.048)	(0.048)	(0.124)	(0.125)	(0.048)
lnmilk	0.311***	0.358***	0.427***	0.428***	0.309***
	(0.007)	(0.007)	(0.068)	(0.068)	(0.008)
Fixed costs share	0.039***	0.044***	0.039***	0.039***	0.040***
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)
Own Labor (100h)	5.650e-6	-2.942e-4	-6.452e-4	-0.001	9.150e-5
	(3.733e-4)	(3.736e-4)	(4.182e-4)	(4.188e-4)	(4.673e-4)
Stocking density	-0.021***	-0.020***	-0.003*	-0.003*	-0.019***
	(0.004)	(0.005)	(0.002)	(0.002)	(0.004)
Deviation of input from optimal value	-3.068***	-3.202***	-3.733***	-3.736***	-3.054***
	(0.063)	(0.062)	(0.362)	(0.363)	(0.072)
Share medium processors	-0.078***	-0.076***			-0.080***
	(0.006)	(0.006)			(0.006)
Share large processors	0.017***	0.017***			0.018***
	(0.002)	(0.002)			(0.002)
Share medium retailers	-0.002	-0.003			0.003
	(0.007)	(0.007)			(0.006)
Share large retailers	9.360e-5	-0.002			-0.001
	(0.003)	(0.003)			(0.003)
Partnership	-0.199***	-0.199***	-0.284***	-0.284***	-0.198***
	(0.019)	(0.019)	(0.053)	(0.053)	(0.023)
Other legal form	-0.835***	-0.676***	-1.093***	-1.095***	-0.828***
	(0.029)	(0.029)	(0.180)	(0.180)	(0.033)
Constant	-0.648***	-0.657***	1.495***	1.490***	-1.040***
	(0.105)	(0.136)	(0.438)	(0.440)	(0.111)
Instruments (first-stage)					
L.Organic price premium	1.430***	1.434***	0.410***	0.399***	
	(0.261)	(0.261)	(0.121)	(0.121)	
L.Organic market share	0.049***	0.049***	0.065***	0.065***	
	(0.002)	(0.002)	(0.001)	(0.001)	
Country fixed-effects	Yes	No	Yes	Yes	Yes
FADN region fixed-effects	No	Yes	No	No	No
Year fixed-effects	Yes	Yes	Yes	Yes	Yes
Corr(e_Org; e_ μ)	-0.070***	-0.071***	-3.775e-4	-1.192e-4	
	(0.007)	(0.007)	(0.005)	(0.005)	
Log Pseudo Likelihood	-115,035.04	-114,165.59	-257,343.56	-256,589.57	
Wald χ^2	101,803.05***	117,489.85***	240,597.86***	239, 944.55***	
F-value					2323.480***
R^2					0.720
Number of obs.	65,008	65,008	143,899	143,454	65,326

Notes: *** p<0.01, ** p<0.05, * p<0.1. Heteroskedasticity robust standard errors in parentheses

Regarding farm profits, we also find a positive effect of organic production. The results in Table 4 show that on average organic farms generate ROA that are between 0.8 and 6.4 %-points higher than those of conventional farms (columns 5-7). The signs for the control variables mainly resemble those for the markup case.

Table 4. Effect of organic farming on profitability (ROA)

Variable	(1) Country fixed-effects	(2) FADN region fixed-effects	(3) Downstream variables excluded	(4) Without transition	(5) OLS
Lag ROA	0.719***	0.695***	0.545***	0.544***	0.725***
	(0.011)	(0.011)	(0.020)	(0.020)	(0.013)
Org	0.057***	0.054***	0.003	0.003	0.006***
	(0.005)	(0.005)	(0.002)	(0.002)	(0.001)
lnmilk	0.005***	0.005***	0.003***	0.003***	0.004***
	(2.434e-4)	(2.597e-4)	(1.530e-4)	(1.535e-4)	(2.507e-4)
Own Labor (100h)	9.560e-5***	1.242e-4***	1.652e-4***	1.645e-4***	8.990e-5***
	(1.850e-5)	(1.820e-5)	(1.360e-5)	(1.360e-5)	(1.880e-5)
Stocking density	-0.001***	2.484e-4	3.841e-4***	3.916e-4***	-0.001***
	(2.154e-4)	(2.567e-4)	(8.360e-5)	(8.410e-5)	(2.419e-4)
Deviation of input from optimal value	-0.007***	-0.007***	0.002	0.002	-0.003
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
Share medium processors	-0.005***	-0.005***			-0.006***
	(2.865e-4)	(2.841e-4)			(3.038e-4)
Share large processors	0.001***	4.842e-4***			0.001***
	(1.119e-4)	(1.106e-4)			(1.028e-4)
Share medium retailers	0.003***	0.003***			0.003***
	(4.436e-4)	(4.376e-4)			(4.435e-4)
Share large retailers	-3.742e-4**	-3.472e-4**			-0.001***
	(1.546e-4)	(1.548e-4)			(1.422e-4)
Partnership	-0.002***	-0.002*	0.001	0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Other legal form	-0.019***	-0.014***	-0.019***	-0.019***	-0.018***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Constant	0.009*	-0.026***	0.039***	0.039***	0.018***
	(0.005)	(0.007)	(0.002)	(0.002)	(0.004)
Instruments (first-stage)					
L.Organic price premium	1.699***	1.724***	0.870***	0.865***	
	(0.133)	(0.134)	(0.078)	(0.078)	
L.Organic market share	0.087***	0.088***	0.083***	0.083***	
	(0.002)	(0.002)	(0.001)	(0.001)	
Country fixed-effects	Yes	No	Yes	Yes	Yes
FADN region fixed-effects	No	Yes	No	No	No
Year fixed-effects	Yes	Yes	Yes	Yes	Yes
Corr(e_Org; e_ π)	-0.422***	-0.397***	0.037*	0.037*	
	(0.040)	(0.040)	(0.021)	(0.021)	
Log Pseudo Likelihood	81,732.174	82,348.216	196,617.000	196,088.920	
Wald χ^2	25,995.51***	30,522.74***	82,394.49***	82,119.14***	
F-value					788,38***
R^2					0.637
Number of obs.	65,008	65,008	144,037	143,595	65,326

Notes: *** p<0.01, ** p<0.05, * p<0.1. Heteroskedasticity robust standard errors in parenthes

Regarding the instruments the first-stage results (see Table A1 in the appendix) reveal that the lagged organic price premium and the organic market share are as expected positively related to the decision of converting to organic farming. Finally, the correlation coefficients of the error terms of the first and second-stage equations reported in the bottom column of Table 3 are statistically significant in all but one model. This implies that the nullhypothesis of "no endogeneity in the management strategy regarding organic farming" is rejected and highlights that an IV approach should be applied. Finally, we calculate for all models tests of the overidentifying restrictions based on a standard 2SLS procedure. The test statistics reported in Tables 3 and 4 are insignificant which suggests that the instruments are valid. Note that in some cases due to significant test statistics we had to exclude organic market share as an instrument from the first stage.

Results for the survivorship analysis to investigate the drivers of conversion back to conventional farming are reported in Table 5. The results show that the exit probability decreases with experience in the organic market. Moreover, the exit probability is as expected negatively related to the organic price premium (column 1). In columns 2 and 3 of Table 5 we also include the volatility measures to the regression. As only a single volatility measure can be calculated for each firm the panel reduces to a cross section in these analyses and we use mean values of the remaining independent variables. The results show that particularly high volatility in profitability increases the probability to revert back to conventional farming. Figure 2 confirms that the exit probability decreases over time but reveals a peak in the probability to convert back to organic farming in the second year after transition. Subsequently we observe a decline in the exit probability with increasing experience in the organic market.

Table 5. Survivorship analysis

Variable	(1)	(2)	(3)
Constant	-2.451***	-1.197**	-1.704***
	(0.226)	(0.575)	(0.617)
time	-0.111***		
	(0.026)		
L.Organic price premium	-5.233***	-15.949***	-14.333***
	(1.192)	(4.844)	(5.095)
L.Organic market share	-0.090***	-0.034	-0.057
	(0.012)	(0.053)	(0.057)
lnmilk	0.022	0.038	0.010
	(0.044)	(0.082)	(0.085)
Own Labor (100h)	0.004	0.004	0.006
	(0.003)	(0.004)	(0.005)
Stocking density	0.036	0.150	0.162
	(0.072)	0.138	(0.157)
Deviation of input from optimal value	-15.156***	-5.709***	-5.445***
	(0.863)	(1.302)	(1.346)
Partnership	0.425**		
	(0.170)		
Other legal form	0.189		
	(0.237)		
Volatility in markup		-0.237	
		(0.307)	
Volatility in ROA			0.250**
			(0.113)
Log Likelihood	-1,150.204		
Wald χ^2	425.840***		
LR χ^2		236.680***	225.950***
Obs.	8,009	1,518	1,427

Notes: *** p<0.01, ** p<0.05, * p<0.1; Dependent variable is Exit dummy.

For columns (2) and (3) the independent variables are means over time.

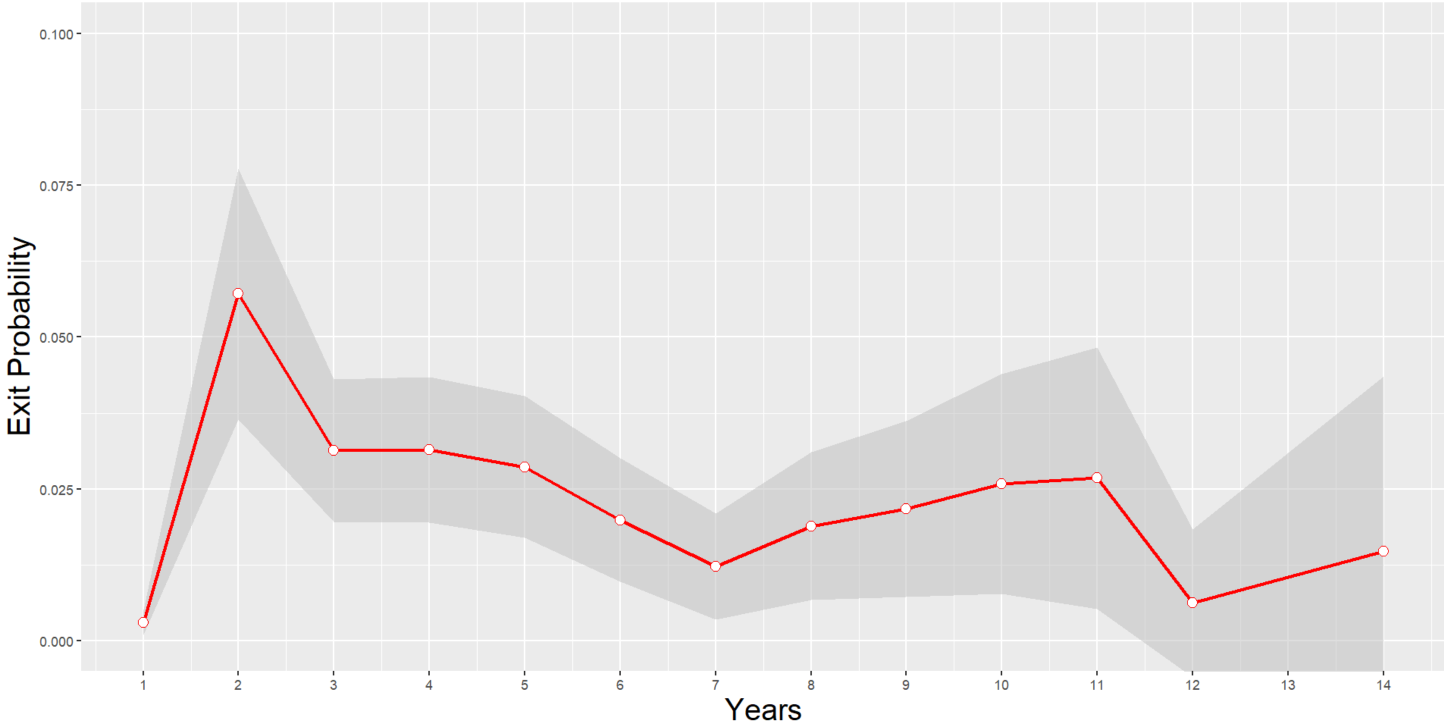


Figure 2: Exit probability for years after entering organic market

5. Conclusions

This article analyzes the relationship of management strategies related to organic farming and farm performance for the EU dairy sector. Organic agriculture is a widely established production system that can help to achieve various sustainability goals. Accordingly, the markets of organically produced food have experienced a steep incline during the past decades. The further expansion of organic farming however, crucially depends on its financial competitiveness compared to conventional farming. We apply novel approaches to analyze the causal effect of farmers' decision to pursue organic farming on farm performance measured by price markups over marginal cost and profitability. We account for endogeneity in the decision to convert to organic farming using an extended regression approach, and evaluate the probability of exiting the organic market. Our results reveal that organic farms generate higher markups and tend to be more profitable compared to conventional farming. However, our results point towards a peak in the exit probability in the second year after transitioning to organic farming. The results thus provide insights that may help to reach the political targets with regards to the market share of organic agriculture. Policy makers might provide farmers who seek to convert to organic agriculture with best demonstrated practices for organic farming to facilitate the learning process. They could further foster the build up of networks which entering organic farmers could join. Such networks contribute to the dissemination of knowledge on farming practices.

References

Alem, H., Lien, G., Kumbhakar, S. C., & Hardaker, J. B. (2019). Are diversification and structural change good policy? An empirical analysis of Norwegian agriculture. *Journal of Agricultural and Applied Economics, 51*(1), 1–26.

Autor, D., Dorn, D., Katz, L.F., Patterson, C., & van Reenen, J. (2020). The Fall of the Labor Share and the Rise of Superstar Firms. *Quarterly Journal of Economics, 135*(2), 645-709.

Battese, G. E. (1997). A note on the estimation of Cobb-Douglas production functions when some explanatory variables have zero values. *Journal of Agricultural Economics, 48*, 250–252.

Bolwig, S., Gibbon, P., and Jones, S. (2009). The Economics of Smallholder Organic Contract Farming in Tropical Africa. *World Development*, 37(6), 1094-1104.

Brady, M.P., Granatstein, D., & Kirby E. (2023). Survival and growth of organic farms over the long-run. *Journal of the Agricultural and Applied Economics Association*, 2(2), 248-262.

Cameron, A.C. & Trivedi, P.K. (2022). Microeconometrics Using Stata. Volume II: Nonlinear Models and Causal Inference Methods 2nd edition. Stata Press.

Clark, SF. (2009). The Profitability of Transitioning to Organic Grain Crops in Indiana. *American Journal of Agricultural Economics*, 91(5), 1497-1504.

Coelli, T. J., Rao, D., O'Donnell, C. J., & Battese, G. E. (2005). *An Introduction to Efficiency and Productivity Analysis* (2nd ed.). New York: Springer.

Crowder, D.W. and Reganold, J.P. (2015). Financial competitiveness of organic agriculture on a global scale. *PNAS*, 112 (24): 7611-7616.

De Frahan, B. H., Baudry, A., De Blander, R., Polome, P., & Howitt, R. (2011). Dairy farms without quotas in Belgium: estimation and simulation with a flexible cost function. *European Review of Agricultural Economics*, *38*(4), 469–495.
De Loecker, J., & Warzynski, F. (2012). Markups and Firm-Level Export Status. *American Economic Review*, *102*(6), 2437-2471.
De Loecker, J., Goldberg, P. K., Khandelwal, A. K., & Pavcnik, N. (2016). Prices, Markups, and Trade Reform. *Econometrica*, *84*(2), 445–510.
De Loecker, J, Eeckhout, J., and Unger, G. (2020). The Rise of Market Power and the Macroeconomic Implications. *The Quarterly Journal of Economics*, 135(2): 561-644.

De Schutter, O. (2014). Report of the Special Rapporteur on the right to food. United Nations.

Diewert, W. E., & Wales, T. J. (1987). Flexible functional forms and global curvature conditions. *Econometrica*, *55*(1), 43–68.
European Commission (2021). On an action plan for the development of organic production. Communication from the commission to the European Parliament, the Council, The European Economic and Social Committee and the Committee of the Regions. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:13dc912c-a1a5-11eb-b85c-01aa75ed71a1.0003.02/DOC_1&format=PDF (last: 04.10.2023).
European Commission (2023). Organic action plan. Available at: https://agriculture.ec.europa.eu/farming/organic-farming/organic-action-plan_en (last: 18.01.2023).
Eurostat (2020). *Agricultural prices and price indices*. ec.europa.eu/eurostat/web/agriculture/data/database. Accessed 4 December 2020.Eurostat (2023). Developments in organic farming. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Developments_in_organic_farming (last: 04.10.2023).
Froehlich, A.G., Melo, A.S.S.A., Sampaio, B. (2018). Comparing the Profitability of Organic and Conventional Production in Family Farming: Empirical Evidence From Brazil. *Ecological Economics*, 150, 307-314.

Grau, A., and Hockmann, H. (2018). Market power in the German dairy value chain. *Agribusiness*, 34(1), 93–111.Grovermann, C., Quiédeville, S., Muller, A., Leiber, F., Stolze, M., Moakes, S. (2021). Does organic certification make economic sense for dairy farmers in Europe? – A latent class counterfactual analysis. *Agricultural Economics*, 52(6), 1001-1012.

Gullstrand, J., Blander, R. de, & Waldo, S. (2013). The Influence of Biodiversity Provision on the Cost Structure of Swedish Dairy Farming. *Journal of Agricultural Economics*, *65*(1), 87–111.
Hall, R.E. (1973). The Specification of Technology with Several Kinds of Output. *Journal of Political Economy*, *81*(4), 878-892.
Heinze, S. and Vogel, A. (2017). Reversion from Organic to Conventional Agriculture in Germany: An Event History Analysis. *German Journal of Agricultural Economics*, 66(1), 13-25.
Jafari, Y., Koppenberg, M., Hirsch, S., & Heckelei, T. (2023). Markups and export behavior: Firm-level evidence from the French food processing industry. *American Journal of Agricultural Economics*, 105(1): 174-194.
Keane, M. and Neal, T. (2023). Instrument strength in IV estimation and inference: A guide to theory and practice. *Journal of Econometrics*, 235(2): 1625-1653.
Khanal, A.R., Mishra, S.K., Honey, U. (2018). Certified organic food production, financial performance, and farm size: An unconditional quantile regression approach. *Land Use Policy*, 78, 367-376.

Koppenberg, M., & Hirsch, S. (2022). Markup estimation: A comparison of contemporary methods at the example of European food retailers. *Agribusiness*, *38*(1), 108-133.
Koppenberg, M. (2023). Markups, Organic Agriculture and Downstream Concentration at the Example of European Dairy Farmers. *Agricultural Economics*, 54(2), 161-178.
Kumbhakar, S.C., Baardsen, S., & Lien, G. (2012). A New Method for Estimating Market Power with an Application to Norwegian Sawmilling. *Review of Industrial Organization, 40*(2), 109-129.
Lal, A., Lockhart, M.W., Xu, Y., Zu, Z. (2021). How Much Should We Trust Instrumental Variable Estimates in Political Science? Practical Advice based on Over 60 Replicated Studies. Available at SSRN: https://ssrn.com/abstract=3905329.

Lee, H., & Van Cayseele, P. (2022). Market power, markup volatility and the role of cooperatives in the food value chain: evidence from Italy. *European Review of Agricultural Economics*, 1-49.

Lence, S.H., & Miller, D.J. (1998). Estimation of multi-output production functions with incomplete data: A generalized maximum entropy approach. *European Review of Agricultural Economics, 25*(2), 188-209.

Liu, Y., Hu, W., Jetté-Nantel, S., & Tian, Z. (2014). The Influence of Labor Price Change on Agricultural Machinery Usage in Chinese Agriculture. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 62(2), 219–243.
Madelrieux, S. and Alavoine-Mornas, F. (2013). Withdrawal from organic farming in France. *Agronomy for Sustainable Development*, 33, 457-468.Marton, T.A. and Storm, H. (2021). The case of organic dairy conversion in Norway: Assessment of multivariate neighbourhood effects. *Q Open*, 1, 1-17.

Morey, E.R. (1986). An introduction to checking, testing, and imposing curvature properties: the true function and the estimated function. *Canadion Journal of Economics, 19*(2), 207-235.

Morlacco, M. (2020). *Market Power in Input Markets: Theory and Evidence from French Manufacturing.* University of Southern California. sites.google.com/view/monicamorlacco/research. Accessed 12 May 2021.

Mosheim, R., & Knox Lovell, C. A. (2009). Scale Economies and Inefficiency of U.S. Dairy Farms. *American Journal of Agricultural Economics*, 91(3), 777–794.
Pieters, H. and Swinnen, J. (2016). Trading-off volatility and distortions? Food policy during price spikes. *Food Policy*, 61, 27-39.
Rasmussen, S. (2010). Scale efficiency in Danish agriculture: an input distance-function approach. *Journal of Agricultural Economics*, 37(3), 335–367.
Rattanasuteerakul, K. and Thapa, G.B. (2012). Status and financial performance of organic vegetable farming in northeast Thailand. *Land Use Policy*, 29(2), 456-463.

Ray, S. C. (1982). A Translog Cost Function Analysis of U.S. Agriculture, 1939-1977. *American Journal of Agricultural Economics*, 64(3), 490–498.
Renner, S., Glauben, T., & Hockmann, H. (2014). Measurement and decomposition of flexibility of multi-output firms. *European Review of Agricultural Economics*, *41*(5), 745-773.Rosati A. and Aumaitre, A. (2004). Organic dairy farming in Europe. *Livestock Production Science*, 90, 41-51.
Sahm, H., Sanders, J., Nieberg, H., Behrens, G., Kuhnert, H., Strohm, R., Hamm, U. (2013). Reversion from organic to conventional agriculture: A review. *Renewable Agriculture and Food Systems*, 28(3), 263-275.
Salvanes, K.G., & Tjøtta, S. (1998). A Note on the Importance of Testing for Regularities for Estimated Flexible Functions Forms. *Journal of Productivity Analysis*, *9*, 133-143.

Sexton, R. J., and Xia, T. (2018). Increasing Concentration in the Agricultural Supply Chain: Implications for Market Power and Sector Performance. *Annual Review of Resource Economics*, 10(1), 229–251.

Skevas, I., Emvalomatis, G., & Brümmer, B. (2018). The effect of farm characteristics on the persistence of technical efficiency: a case study in German dairy farming. *European Review of Agricultural Economics, 45*(1), 3-25.

Stata Press (2019). “Extended Regression Models Reference Manual.” https://www.stata.com/bookstore/extended-regressionmodels-reference-manual/.

Tran, D. and Goto, D. (2019). Impacts of sustainability certification on farm income: Evidence from smallscale specialty green tea farmers in Vietnam. *Food Policy*, 83, 70-82.

Uematsu, H., & Mishra, A. K. (2012). Organic farmers or conventional farmers: Where's the money? *Ecological Economics*, 78, 55–62.

USDA (2019). Organic Agriculture. Available at: https://www.ers.usda.gov/agriculture-improvement-act-of-2018-highlights-and-implications/organic-agriculture/ (last: 18.01.2023).

Villano, R., Bravo-Ureta, B., Solís, D., & Fleming, E. (2015). Modern Rice Technologies and Productivity in the Philippines: Disentangling Technology from Managerial Gaps. *Journal of Agricultural Economics*, *66*(1), 129–154.

Wieck, C., & Heckelei, T. (2007). Determinants, differentiation, and development of short-term marginal costs in dairy production: an empirical analysis for selected regions of the EU. *Agricultural Economics, 36*(2), 203–220.

Wimmer, S., & Sauer, J. (2020). Diversification economies in dairy farming – empirical evidence from Germany. *European Review of Agricultural Economics, 47*(3), 1338–1365.

Appendix

Table A1. First-stage regressions for the effect of organic farming on markups and profitability

Variable	**Markup**				**Profitability**			
	(1) Country fixed-effects	(2) FADN region fixed-effects	(3) Downstream variables excluded	(4) Without transition	(5) Country fixed-effects	(6) FADN region fixed-effects	(7) Downstream variables excluded	(8) Without transition
lnmilk	-0.031***	-0.030***	-0.021***	-0.021***	-0.067***	-0.064***	-0.031***	-0.031***
	(0.009)	(0.009)	(0.005)	(0.005)	(0.007)	(0.007)	(0.005)	(0.005)
Fixed costs share	0.049***	0.049***	0.027***	0.027***				
	(0.002)	(0.002)	(0.001)	(0.001)				
Own Labor (100h)	0.005***	0.006***	0.003***	0.003***	-4.124e-4	-0.001	3.642e-4	3.614e-4
	(0.001)	(0.001)	(4.144e-4)	(4.150e-4)	(0.001)	(0.001)	(3.795e-4)	(3.800e-4)
Stocking density	-0.235***	-0.228***	-0.324***	-0.325***	-0.299***	-0.312***	-0.327***	-0.328***
	(0.026)	(0.026)	(0.019)	(0.019)	(0.020)	(0.020)	(0.013)	(0.013)
Deviation of input from optimal value	0.231***	0.230***	0.156***	0.146***	0.297***	0.306***	0.459***	0.449***
	(0.075)	(0.075)	(0.045)	(0.045)	(0.070)	(0.071)	(0.042)	(0.042)
Share medium processors	-0.021**	-0.021**			-0.005	-0.005		
	(0.010)	(0.010)			(0.011)	(0.011)		
Share large processors	0.027***	0.027***			0.002	0.002		
	(0.003)	(0.003)			(0.003)	(0.003)		
Share medium retailers	0.010***	0.010***			0.006**	0.006***		
	(0.003)	(0.003)			(0.002)	(0.002)		
Share large retailers	0.005	0.005			0.020***	0.021***		
	(0.004)	(0.004)			(0.004)	(0.004)		
Partnership	-0.016	-0.170	-0.099***	-0.098***	0.212***	0.219***	0.080***	0.081***
	(0.035)	(0.035)	(0.021)	(0.021)	(0.032)	(0.032)	(0.020)	(0.020)
Other legal form	-0.162***	-0.165***	-0.365***	-0.367***	-0.073*	-0.093**	-0.320***	-0.321***
	(0.045)	(0.045)	(0.029)	(0.029)	(0.039)	(0.040)	(0.028)	(0.028)
Constant	-5.794***	-5.786***	-3.420***	-3.418***	-2.500***	-2.496***	-1.932***	-1.929***
	(0.166)	(0.166)	(0.045)	(0.045)	(0.106)	(0.107)	(0.025)	(0.025)
Instruments								
L.Organic price premium	1.430***	1.434***	0.410***	0.399***	1.699***	1.724***	0.870***	0.865***
	(0.261)	(0.261)	(0.121)	(0.121)	(0.133)	(0.134)	(0.078)	(0.078)
L.Organic market share	0.049***	0.049***	0.065***	0.065***	0.087***	0.088***	0.083***	0.083***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)

Notes: *** p<0.01, ** p<0.05, * p<0.1. Heteroskedasticity robust standard errors in parentheses