Impact of the War in Ukraine on Farm Profitability and the Attractiveness of Environmental Measures in Germany

Raphaela Ellßel, Friedrich Wüstemann, Frank Offermann and Thomas de Witte
Thünen Institute of Farm Economics, Braunschweig

Abstract

The war in Ukraine has led to massive price increases for agricultural inputs and products. This paper examines the effects on farm profitability and the consequences for the adoption of eco-schemes on arable farms. We use the large farm sample of the German Farm Accounting Data Network (FADN) to identify the average income effects and to highlight the heterogeneity of the effects and their drivers. Building on these results, we analyse farms' adaptation strategies with a focus on changes in nitrogen input intensity and participation in environmental measures ("eco-schemes") of the new Common Agriculture Policy (CAP).

Our results suggest that income effects are heterogeneous and subject to considerable uncertainty about the near future, and that many farms are likely to benefit from the short-term price effects of the war in Ukraine. Against this background, the efficiency of financial assistance under the EU crisis reserve would have benefited from a stronger focus on liquidity loans and ex-post hardship support. Our analysis also shows strong implications for participation in eco-schemes. The results cast significant doubts on the effectiveness and efficiency of the eco-schemes introduced by the new CAP, beyond the observed impact of the war in Ukraine.

Keywords

Ukraine war; income; eco-schemes; CAP; nitrogen fertilisation

1 Introduction

Ukraine and Russia are major producers and exporters of cereals and fertilisers. The war in the Ukraine has disrupted global trade flows for these commodities and led to a sharp rise in prices. In addition, as Russia is the world's largest exporter of natural gas and a major exporter of crude oil, European political and trade sanctions against Russia have contributed to a strong increase in energy costs. The situation is developing very dynamically, and the short-term impact on agricultural production and income in the EU can be conclusively assessed only at the end of the year. In particular, developments beyond the current marketing year are difficult to predict (GLAUBEN et al., 2022) and a comprehensive analysis is lacking regarding the immediate consequences of the war for EU farmers' incomes and the impact of the changed framework conditions on the achievement of the objectives of the EU's CAP.

Despite, or precisely because of, this uncertainty, the EU Commission swiftly adopted crisis measures under Article 219 of the common market organisation (Regulation (EU) No 1308/2013) on 24 March 2022. This is the first time since the establishment of this instrument in 2013 that financial resources from the crises reserve have been used to directly support farmers. The EU Commission has released 500 mill. € from the EU Budget and allows member states to top up these funds by up to 200% via national budgets. Germany will make use of this possibility and distribute 180 mill. € to farmers most affected by the price impacts of the war. EU administrative rules require the aid to be disbursed by the end of September 2022, which poses major challenges for the Administration, including a timely, likely pragmatic, assessment of farmers' need for compensatory payments. At the same time, policy makers need to assess and possibly respond to potential detrimental effects on policy objectives. While immediate concerns have focused on impacts on food security, impacts on the environmental objectives of the CAP are receiving increasing attention. Changes in product and input prices can affect production intensity, particularly the use of nitrogen fertiliser as a key factor in many environmental issues.

Also, a key element of agri-environmental measures of the new CAP from 2023 onward is the implementation of so-called "eco-schemes", voluntary measures for which additional payments are made from the CAP budget (EUROPEAN COMMISSION, 2022). However, farmers will make use of this option only if it is profitable for them. Short-term market expectations play an important role in this decision, as farmers implement these agri-environmental schemes

DOI: 10.30430/gjae.2022.0300

voluntarily and can decide annually whether and which ones to implement. Given the heterogeneity of farmers' compliance costs and the nationwide uniform payment level for each eco-scheme (LWK NIEDERSACHSEN, 2022), large differences between farms and regions are expected in terms of the impact on the economic incentive to participate in the schemes.

Against this background, our aim is to estimate the short-term effects of the war-related price changes on farmers in Germany in a representative manner for the first time, and to analyse how the changed framework conditions will affect nitrogen fertiliser use and the participation of farmers in the new eco-schemes in 2023.

To this end, we derive price scenarios to isolate the effects of the war in Ukraine on price developments, and apply these scenarios to the large farm sample of the German FADN. We calculate the short-term impact on profits for different farm types to show the heterogeneity and drivers of the impacts. We then analyse the impact on the acceptance of eco-schemes in two typical arable farms, considering in detail farm adaptation strategies that can be implemented for harvest year 2023. For one of the most important eco-schemes, we scale up the impacts on total participation and budget using a FADN-based programming model. We conclude with a discussion of political implications and recommendations for the design of the analysed policy measures.

2 Methods and Material

We derive price scenarios for 2022 and 2023 using the market data available at the time of the analysis. Short-term impacts on farm income are calculated using the large farm sample of the German FADN. In the medium term (2023 ff), the large price changes will lead to diverse adjustments on the farms. We, therefore, use a mathematical programming model based on farm accountancy data to estimate the income effects for 2023, and we consider in detail farm adaptation strategies, taking into account farm individual restrictions and their effects on the acceptance of eco-schemes in typical arable farms.

2.1 Derivation of Price Scenarios

Russia's invasion of Ukraine has led to massive price increases for important agricultural inputs as well as agricultural products. However, prices are influenced by a multitude of factors (supply, demand, expectations), so that a clear attribution of observed price changes to a single event is difficult. This is particularly true against the background of the dynamic price increases for many inputs and agricultural products that already could be observed in the months before the start of the Ukraine war. The price developments since the beginning of the Ukraine war also are extremely dynamic, with price declines from the peak values being observed for some products and inputs. A narrow time corridor around the time of the start of the Ukraine war is therefore chosen in order to estimate the influence on the observed prices and on price expectations.

Short-Term Scenario

For the analysis of short-term income impacts, we calculate expected income using expected prices at two distinct periods, representing the situation before the start of the war (January 2022) and after the war had started (week 13/2022 - i.e., end March/beginning of April 2022). Price changes generally affect farm profits only when purchases or sales or contracts are concluded. The impact of the Ukraine war, therefore, varies greatly from farm to farm, depending on when inputs are purchased and products are sold. On the sales side, three fundamentally different effects of the price changes are conceivable:

- If a farm still has unsold stocks from the 2021 harvest, the increase in current price levels will lead to a respective revaluation of stock. This is particularly relevant for storable crop products and is taken into account in our calculations for cereals and rape. On 31.12.2021, approximately 25% to 30% of the 2021 grain harvest was still stored by farms (BMEL, 2022). For the calculations, an average stock level of 25% of the grain harvest and 20% of the rapeseed harvest in 2021 is assumed.
- For the part of the 2022 harvest already sold/hedged via forward contracts before the start of the Ukraine war, the current price increase and future price developments have no impact on expected profits. For the calculations, it is assumed, on the basis of expert estimates, that 50% of the expected grain and rapeseed harvest already was contracted at the corresponding futures price in January 2022. Precontracted prices also are very important for sugar beets and potatoes. For the calculations, due to missing information on future prices, we assume that sugar beets and potatoes are sold at the price of the previous year (2021),

which tends to underestimate the respective revenues.[1]

- For the share of the 2022 production not yet sold/hedged, we use the expected prices at time of sale. We use futures prices where available (e.g. futures quotations for contracts maturing in September 2022 grain, oilseeds and wheat) as an indicator of price expectations for the 2022 harvest. For those products for which no futures prices are available, we use derived prices. For example, we use a calculated expected raw milk price based on futures prices for milk powder and butter in December 2022 (TOP AGRAR ONLINE, 2022), and we base the expected prices of energy inputs (e.g. heating oil) on the futures prices for raw oil at the end of 2022. For products with no suitable futures price indicator, we use a naive price expectation based on the most recent farm gate prices received.[2] We assume a linear adjustment of prices over time between the last observed spot price and the expected price at the end of 2022.

For products of crop and livestock production for which no prices are given and thus no price developments are available, the price developments of the products that are factually closest to them are used (e.g. the price developments of wheat for other cereals and of male calves for all calves up to six months of age).

Price changes are taken into account for inputs for which a direct influence of the Ukraine war can be expected due to the dominant market position of Ukraine or Russia. These are fertilisers, energy sources and animal feed. On the input expenditure side, the following impacts of price changes may occur:

- For inputs already purchased or contracted at a fixed price, the current price increase and future price developments have no impact. For the calculations, it is assumed, on the basis of expert estimates, that, on average, 50% of the required fertilisers were already purchased in January 2022.
- For inputs still to be purchased after the start of the war, the price at the date of purchase is relevant. For fertilisers, the calculations are based on the observed purchase prices at the time of calendar week 13. Energy prices are extrapolated until the end of the year with the development of the futures price for crude oil. For animal feed, the purchase prices in January are used as a basis and extrapolated with the development of the futures prices for wheat and rapeseed until the end of the year. The prices estimated in this way are higher than the prices observed at calendar week 13 and imply a transfer of the expected price increases for raw products to the feed mixtures over the course of the year.

The average expected price results from the weighted average of prices at different selling/purchasing times. The formation of the expected value is product specific. Table 1 provides an overview of observed and expected prices for key products and inputs.

Scenario for 2023

While price assumptions for marketing the 2022 harvest are required to analyse the income effects, it is necessary to assume short-term future price expectations for the upcoming harvest in 2023 to be able to analyse the profitability and acceptance of eco-schemes. The reason is that from an agronomic point of view, farmers must take their decision whether to participate in eco-schemes before sowing winter crops in the autumn. Respectively, the price expectations of the upcoming crops will influence this decision. The development of futures prices at the Marché à Terme International de France (MATIF) is a widely accepted source for current short- and medium-term price expectations. Therefore, rapeseed futures maturing in August 2023, November 2023 and February 2024 and wheat futures maturing in September 2023, December 2023 and March 2024 are used to estimate short-term price expectations. During the second quarter of 2022, the mentioned futures averaged 322 €/t for wheat and 705 €/t for rapeseed. To account for quality differences and transport costs between the delivery points and farm gate prices, a base of 14 €/t for bread wheat and 12 €/t for rapeseed is considered. This basis is derived from monthly differences between the nearby MATIF futures and the average farm gate prices reported by the Agrarmarkt Informations-Gesellschaft (AMI). The prices for other internationally traded commodities are derived based on historical price ratios. For sugar beets, the current contract offers from industry are used to assume the sugar beet prices for 2023. Current offers for one-year flexible beet contracts are offered with a minimum price of 37 €/t (NORDZUCKER, 2022). However, due to rising sugar prices on the spot market, beet prices above

[1] Sugar factories have, however, already indicated that they will raise prices to ensure the competitiveness of beet production.

[2] For vegetables and fruits, the impact on prices cannot yet be assessed due to the strong seasonal nature of supply and demand. Farms specialized in these products were therefore excluded in the analysis.

Table 1. Observed and expected prices for key products and inputs before and after the start of the Ukrainian war

	Unit	Observed prices (€)		Expected value of average realised price in 2022 (accounting for average stocks, precontracts and time of sale) (€)	
		in Jan 22	in week 13	in Jan 22	in week 13
Products					
Wheat	t	265	370	253	306
Barley	t	237	342	226	283
Maize	t	243	362	232	299
Rapeseed	t	730	926	615	728
Milk	100 kg	41.6	44.6	45.5	53.1
Beef (young bulls)	kg cw	4.85	5.87	4.85	5.7
Male calves (bulls HF)	animal	71	95	71	92.0
Piglets	animal 30 kg	27	60	27	55.9
Fattening pigs	kg cw	1.28	1.95	1.28	1.87
Broiler	kg cw	0.96	1.12	0.96	1.10
Futures/contracts for end of 2022					
Wheat	t	250	330		
Rapeseed	t	592	784		
Milk	100 kg	49	68 [1)]		
Raw oil	barrel	80	100		
Inputs					
Energy					
Agricultural diesel (net)	100 l	97	134	97	129
Electricity	index	123	129 [2)]	123	138
Gas	index	131	144 [2)]	131	150
Heating oil	100 l	76	119 [2)]	76	104
Fertiliser					
N [3)]	kg	2.15	3.21	2.15	2.68
P	kg	1.43	1.56	1.43	1.50
K	kg	0.97	1.16	0.97	1.07
Feedstuff					
Concentrates (dairy, 18% raw protein)	t	303	348	303	362
Concentrates (beef, 20 - 25% raw protein)	t	310	368	310	377
Concentrates (pig fattening)	t	331	401	331	406

Note: [1)]Calculated based on futures for milk powder and butter; [2)]Average of March/April prices; [3)]Based on average of calcium ammonium nitrate (CAN) and urea.
Source: Own calculations using market price observations from various sources (agrarmarkt-nrw.de, ami-informiert.de, bmel-statistik.de/archiv/statistischer-monatsbericht, kaack-terminhandel.de, lfl.bayern.de, lel.landwirtschaft-bw.de, lwk-niedersachsen.de).

40 €/t are currently expected (BECKHOFE, 2022). Against this background, a beet price of 42 €/t is assumed.

Projections for input prices are subject to high uncertainty, and due to the unsecure market situation, no advance contracts are currently available for many inputs. Therefore, observed market prices in June 2022 are used as price expectations for diesel and fertiliser prices in the next season.

Table 2 summarizes the price expectations used for analysis and compares them with the price expectations in 2021 according to RÖDER et al. (2021a), which were used to calculate the payments for the eco-schemes.

Table 2. Price assumptions to analyse the profitability of eco-schemes

	Unit	Price assumption 2021 (RÖDER et al., 2021a)	Price expectation 2023
Output prices			
Wheat	€/t	160	310
Rapeseed	€/t	360	690
Sugar beets	€/t	30	42
Input prices			
N	€/kg N	0.8	2.2
P_2O_5	€/kg P_2O_5	0.8	1.5
K_2O	€/kg K_2O	0.6	1.4
Agricultural diesel (net)	€/l	0.8	1.5

Source: Own assumption based on IGC (2022), AGRARHEUTE (2022), AMI (2022), WIDDEL (2022), NORDZUCKER (2022), RÖDER et al. (2021a).

2.2 Calculation of Short-Term Income Effects

For our impact assessment of the Ukraine war on agricultural income, the farm level data of the German FADN are used. The German FADN includes detailed accounting data and farm characteristics, and is the only representative source of whole-farm microeconomic data in Germany. The latest data set contains the annual accounts of 8,845 farms and refers to the accounting year (AY) 2020.[3]

To determine the income effect of the Ukraine war, income in calendar year 2022 is calculated for two scenarios with different price expectations. These incomes are approximated by applying the price relations derived in section 2.1. Profit-increasing production adjustments to the changed price conditions were not considered, as the possibilities for short-term adjustments are extremely limited. The calculations are made at individual farm level. The results are weighted and aggregated for selected farm types. The income indicator used is profit plus wages per worker, which allows evaluating the income of natural and legal persons together.

2.3 Assessment of the Profitability and Adoption of Eco-Schemes

As indicated in the introduction, the intensity and profitability of arable farming vary among regions and result in different opportunity costs for changes in the production systems and thus also for the implementation of eco-schemes. To address these differences, we analyse the implementation costs of eco-schemes on two typical farms (CHIBANDA et al., 2020) by using the single farm simulation model TYPICROP (NEHRING, 2011). The selected farms indicate the range of different farming intensities in Germany. One typical farm is therefore located in the area of South-Hanover, representing farms with very fertile soils and a high level of precipitation. On the 200 ha farm, sugar beets, winter wheat, winter barley, rapeseed and corn silage for biogas are cultivated. The other farm, in Brandenburg, represents farms with lower soil quality and precipitation levels. Due to poorer natural conditions, rapeseed, winter wheat, corn silage and rye are grown on 1,200 ha with a substantially lower yield.

We calculate the implementation costs of the eco-schemes and the impact on price changes based on changes in the gross margin II[4]. For our analysis, we focus on four most relevant eco-schemes for arable farming, which are described in Table 3. The applied price scenarios for inputs and outputs are described in chapter 2.1.

For the opportunity costs to implement GAEC 8 (eco-scheme 1a) we calculate the average gross margin II of the crop rotation and reduce it by 20% to reflect that farmers will primarily set aside their poorer performing fields. Additionally, seed costs for a cover crop and operating costs to mulch the green cover are considered. For costs of the top-up for flower strips (eco-scheme 1b), higher seed costs as well higher operating costs are considered as the flowering plants must be reseeded every second year.

The implementation costs of the eco-scheme 2 (diversified crop rotation) are derived from the difference of the gross margin II between the new and displaced crops.

As eco-scheme 6 (crop management without pesticides) is available only for selected summer crops and the expected yield loss will not justify a renunciation of pesticides in sugar beets and potatoes (see RÖDER et al., 2021b), the costs will be calculated only for corn, peas and fava beans. For the cost calculation, forgone revenues resulting from yield losses, savings

[3] In Germany, the accounting year corresponds to a 12-month period, which for many farms does not correspond to the calendar year.

[4] We calculated the gross margin II as the difference between market revenues versus direct costs, variable and fixed machinery costs as well as labor costs.

Table 3. Analysed eco-schemes, compensation payments and requirements

No.	Eco-scheme	Payment	Requirements
1a	Increase GAEC[1] 8 (non-productive land)	Level 1: 4 - 5%: 1,300 €/ha Level 2: 5 - 6%: 500 €/ha Level 3: 6 - 9%: 300 €/ha	Fallow from harvest until August 15th in the following year
1b	Top-up on increased GAEC 8: Flowering plants	150 €/ha	Specifications for composition of seeds, cultivation for following crop from September 1st
2	Diversified crop rotation	30 €/ha	≥ 5 crops, ≥ 10% legumes, ≥ 10 and ≤ 30% share per crop, ≤ 66% cereals
6	Management of arable crops without chemical pesticides	130 €/ha	Summer crops out of list of approved crops, e.g. corn, legumes

Note: [1]GAEC – Good agricultural and ecological condition.
Source: LWK NIEDERSACHSEN (2022).

on pesticides and spraying costs, and additional costs for mechanical weeding are considered. The assumptions regarding additional mechanical weeding passes and yield losses (15% for corn, 30% for peas and fava beans) are taken from RÖDER et al. (2021b).

We supplement the detailed analyses for typical farms with results of the FARMIS model to estimate the impact of these changes in the profitability of eco-scheme 1a (set-aside of arable land) on total adoption and budget use at the sector level. FARMIS is a comparative-static process-analytical programming model for farm groups (DEPPERMANN et al., 2014; EHRMANN, 2017; BRAUN, 2020) used to estimate the income effects for 2023. The specification of FARMIS is based on information from the German FADN, covering about 10,000 farms per year, supplemented by data from farm management manuals (KTBL, 2020). The use of aggregation factors allows for representation of the sectors' production and income indicators. Homogeneous farm groups are generated by the aggregation of single-farm data. For this study, farms were stratified by region, farm type, farm size and management system, resulting in 626 farm groups that represent the German agricultural sector.

2.4 Calculation of the Economic Optimal Nitrogen Rate

According to economic theory, farmers should apply the amount of nitrogen at which the marginal cost of nitrogen fertilizer equals the marginal revenue (MEYER-AURICH and KARATAY, 2019). Therefore, it can be assumed that strong changes in input and output prices will influence farmers' decisions on nitrogen application within the limits of legal regulations. To get a first assessment of how strongly the changed price expectation might influence the nitrogen intensity, we used a quadratic production function based on long-term results from nitrogen response trials conducted by the Lower Saxony Chamber of Agriculture on clay sites (HOWIND, 2021). We considered a 15% yield discount reflecting that yields in field trials are higher than those in practice, since there are no headlands, tramlines or shadows from surrounding vegetation on small test plots (LORENZ et al., 2021). Based on these assumptions, we estimated the following quadratic production function:

$$Y = -0.006\,x^2 + 0.33\,x + 40.61$$

Despite an intensive discussion whether alternative function forms such as the quadratic plateau function or the linear plateau function would be a better fit to describe the production function, the quadratic function is still common and widely used (KAGE et al., 2022; BULLOCK and BULLOCK, 1994; NIGON et al., 2019; MEYER-AURICH and KARATAY, 2019; HENKE et al., 2007). Based on this production function, we calculated the economic optimal nitrogen rate where marginal revenues equal marginal cost for different nitrogen prices and the wheat price expectations described in Table 2.

We did not consider other influencing factors, which were subject to prior research, such as impacts on wheat quality and risk awareness linked to the uncertainty regarding upcoming weather patterns (MEYER-AURICH and KARATAY, 2019; GANDORFER et al., 2011; MEYER-AURICH et al., 2010).

3 Impact of the War in Ukraine

3.1 Income Effects

We estimated the short-term impact of the Ukraine war on the income of German farmers for the calendar year 2022. Table 4 shows the results based on the German FADN and the price ratios in Table 1. The column with the "expected value 1" represents estimated income for 2022 without war in Ukraine and the column with the "expected value 2" with the war.[5]

Our results indicate that higher product prices overcompensate increased input prices for most arable farms. An average additional income of about 9,000 € per worker is calculated comparing the two expected values. For arable farms specialising in cereals, oilseeds and protein, the increase is almost twice as high (around 15,000 € per worker) as the average for all arable farms. It should be noted that for some crop products, such as potato, sugar beets and vegetables, we have assumed constant prices (see chapter 2.1), which, in addition to the different crop rotations in the two groups, may be a reason for the large difference.

For dairy farms, the estimated increase in income is much higher and the income level could more than double compared with previous years. Only for 0.3% of the farms a decrease in income is calculated. The rise in producer price for milk and slaughter cattle, which already began in 2021, was intensified with the beginning of the war. In particular, the assumed milk price increase of 17% largely covers the increased input costs. The rising slaughter prices for beef (e.g. old cows +29%) mainly benefit the other grazing livestock farms, especially farms with extensive forage farming systems. On average, we estimate an increase in income of 5,000 € per worker. However, given the large heterogeneity in this group, the variance among the farms is also high. For one third of the farms, we find a negative income development.

The year 2022 will be another year of low profitability for piglet producers. Since the outbreak of African swine fever in September 2020, prices for piglets and slaughter sows were very low until the beginning of 2022. Combined with rising feed and energy costs, this results in a very high loss of about 61,000 € per worker for expected value 1. Substantial price increases for piglets (+107%) bring expected value 2 into positive range at about 10,000 € per worker, which, however, remains significantly below the level of previous years. For pig fattening farms, the year 2022 could turn out positively due to the raised slaughter prices, after the expected value 1

Table 4. Estimated changes in income due to the war in Ukraine

	Farms in the sample (Number)	Profit plus wages per worker (€)				
		3-year average AY 2018 to AY 2020	AY 2020	Expected value 1 for 2022 based on the price information in January 2022	Expected value 2 for 2022 based on the price information in Week 13 in 2022	Change between the two expected values
Arable farms	2,170	35,560	37,049	40,596	49,559	8,963
of which cereal, oilseed and protein crop farms	1,300	34,854	39,784	48,844	63,994	15,151
Dairy farms	2,277	33,394	33,838	65,138	84,100	18,962
Other grazing livestock farms	780	18,900	19,970	28,721	34,118	5,397
Pig farms	664	39,289	21,776	-23,159	23,608	46,766
of which piglet producer	166	46,509	21,256	-61,079	10,374	71,453
of which pig fattening farms	314	36,057	23,912	19,621	40,637	21,016
Poultry farms	76	50,609	48,537	56,903	60,045	3,142
of which laying hen farms	33	50,556	55,787	67,498	77,016	9,518
of which poultry fattening farms	41	51,384	43,857	49,798	48,118	-1,680

Note: Individual weighting factors are used to extrapolate the sample to the population. The sample size of the analysis is 5,967 farms, extrapolated to 107,563 farms. Only conventional full-time and part-time farms were analysed. The number of farms refers to all columns, except for the column with the 3-year average.
For the laying hen farms, the absolute income level in 2022 cannot be estimated with the data used, as the ban on killing male chicks, which has been in force since the beginning of the year, leads to additional costs compared to the previous year. These additional costs are not due to the Ukraine war.
Source: Own calculations.

[5] Due to different assumptions for the price scenarios, the results in column "expected value 2" differ from the results determined in the context of an analysis for the Federal Ministry of Food and Agriculture (BMEL) on 29 April 2022.

shows only about half the income of the previous years. For pig farms, income increases are projected as a result of the price increases, but with narrow margins, so that the sign of the income change reacts comparatively sensitively to farm-specific cost structures and minor changes in price assumptions.

For laying hen farms, our calculations indicate an income gain. On the other hand, poultry fattening farms record a decrease in income of about 2,000 € per worker due to the increase in feed costs (+21%) and only moderately rising slaughter prices (+15%). However, it should be mentioned that the variance of the income change is high. Our calculations show that half of the farms in the data set experience a negative change and half a positive change. The results for poultry farms should be interpreted with some caution. A large part of the production takes place in large, commercial farms, which are underrepresented in the German FADN. Thus, the transferability of the results to the sector is limited. This is particularly true for laying hen farms where production systems and producer prices are heterogeneous (e.g. barn eggs compared to free-range eggs). Moreover, the level of egg prices suggests that a significant proportion of laying hen farms in the FADN sample produce higher priced eggs and/or have a high share of direct marketing.

To illustrate why the various farm types are affected differently by increasing input and output prices, the shares of the most relevant variable costs on the farm revenues are displayed in Table 5. While the costs for energy and fertiliser have a share below 15% on the farm revenues for all farms, the share of costs for purchased feedstuff is much more relevant for livestock farms and differs widely among the types of livestock farms. It is still comparably low on farms with cattle, sheep and goats due to the high proportion of self-produced feedstuff on grassland, but very high on poultry fattening farms. This explains why the income of poultry fattening farms is especially affected by increasing input costs.

3.2 Profitability of Eco-Schemes

In this chapter, we analyse the impact of the changed price expectation (Table 2) on the profitability of the considered eco-schemes (Table 3) for the two typical farms. Subsequently, we assess sectoral changes in the adoption rate of eco-scheme 1a with FARMIS.

Figure 1 shows the costs and revenues of the two typical farms to provide additional fallow land covered with flowering plants. As described in chapter 2.3, it is assumed that the fallow land displaces the average previous crop rotation. On the typical farm in Brandenburg, the costs of fallow land increase by 430 €/ha, mainly driven by the increasing opportunity costs (+412 €/ha) due to the higher price expectations. Therefore, it is profitable to implement level 1 only under the new price scenario, while level 2 and 3 also were profitable under the historical price expectations.

On the South-Hanoverian farm, only level 1 and 2 were profitable under the historical price scenario. On this farm, the opportunity costs for fallow land increase by 706 €/ha, which is a more than 70% higher increase than on the typical farm in Brandenburg. This difference is mainly driven by the higher yield level. Consequently, only level 1 remains profitable under the changed price expectations.

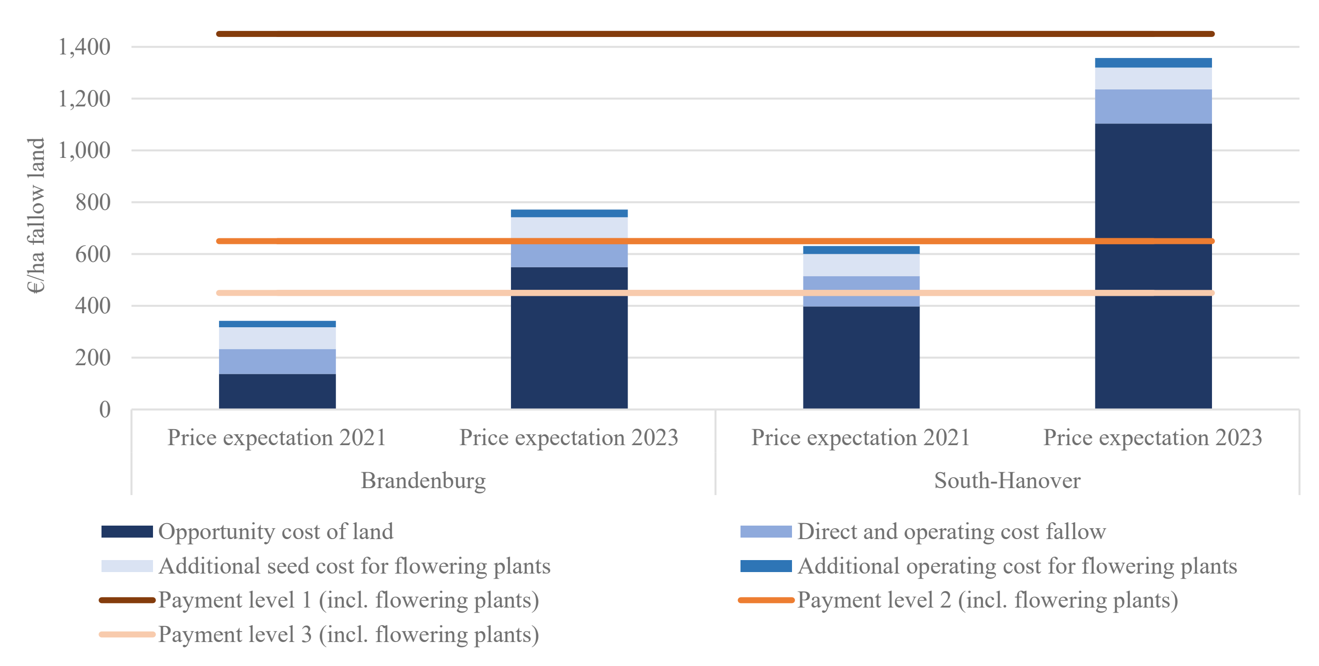
Table 5. Share of costs in total revenues in accounting year 2020

	Farms in the sample (Number)	Share of costs in total revenues (%)		
		Energy	Fertiliser	Purchased feedstuff
Arable farms	2,170	5.9	6.3	1.0
of which cereal, oilseed and protein crop farms	1,300	5.9	7.5	0.3
Dairy farms	2,277	5.9	2.1	16.2
Other grazing livestock farms	780	5.1	2.4	9.0
Pig farms	664	4.2	1.3	27.3
of which piglet producer	166	5.1	1.2	26.8
of which pig fattening farms	314	3.0	1.1	25.0
Poultry farms	76	3.6	0.8	37.7
of which laying hen farms	33	2.8	0.6	24.3
of which poultry fattening farms	41	3.9	0.8	42.9

Note: Individual weighting factors are used to extrapolate the sample to the population. The sample size of the analysis is 5,967 farms, extrapolated to 107,563 farms. Only conventional full-time and part-time farms were analysed.
The revenues also include direct payments under the CAP.

Source: Own calculations.

Figure 1. Profitability of eco-scheme 1 (increase of non-productive arable land with flowering plants)



Source: Own calculations.

However, as level 1 of eco-scheme 1 can be implemented on only 1% of the arable land, the total farm income effects of this eco-scheme are relatively small under the new price expectations.

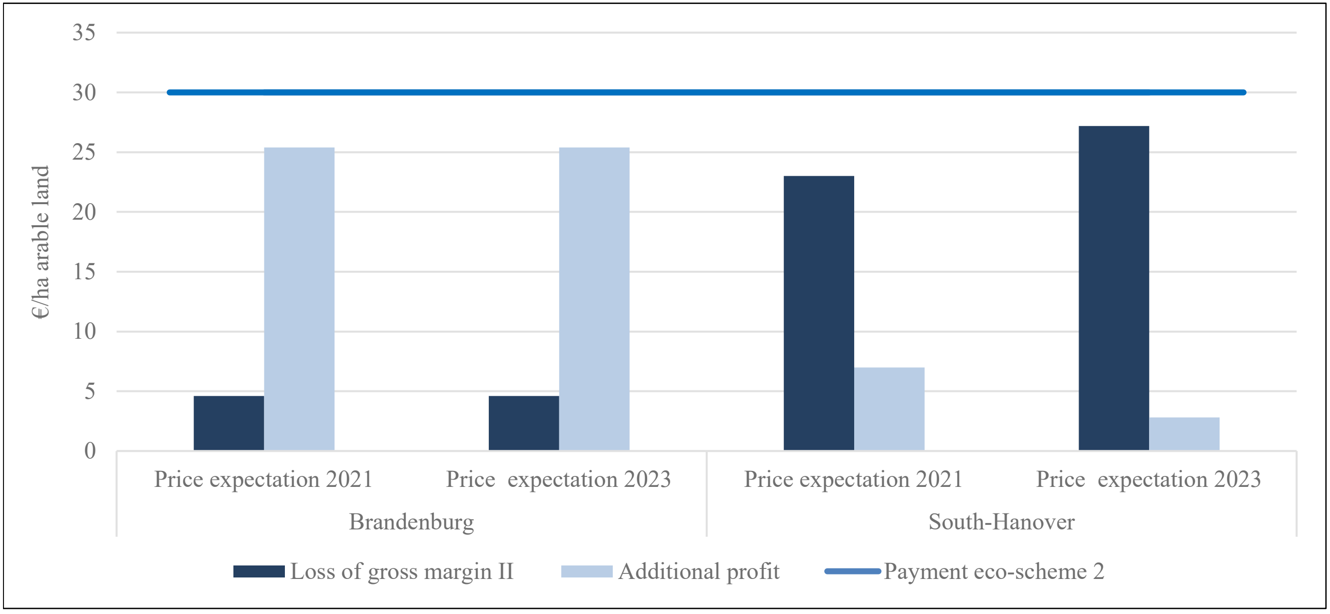
We used the FARMIS model to estimate the impact of these changes in the profitability of eco-scheme 1a on the total adoption (Table 6). The results highlight that projected participation in the scheme is decreasing by 150,000 ha, with the major part of the decrease occurring in areas that were set-aside under level 3 of the scheme under the price expectations from 2021. In line with the calculations for the typical farms, set-aside supported under level 1 of the eco-scheme remains an economically attractive option for almost all of the farms. Due to the differences in the adoption of the different levels of the scheme in the references, the interaction with the set-aside required under conditionality, and the regionally different persistence of landscape elements that are eligible for the scheme, the impact of the changed price expectations differs regionally and by farm type. According to the model results, relative reductions in set-aside area are especially high in Hesse, where the share of set-aside areas under level 3 of the scheme was particularly high in the reference, and in arable farms that more

Table 6. Impact of changed price expectations for 2023 on the expected participation in eco-scheme 1a (increase of non-productive arable land)

	Expected area (ha) under eco-scheme 1a (set-aside of arable land)		
	in 2021	after start of Ukraine war	Change
Schleswig-Holstein	15,894	10,668	-33%
Lower Saxony	46,835	31,198	-33%
North Rhine-Westphalia	13,571	6,642	-51%
Hesse	14,751	4,859	-67%
Rhineland-Palatinate	14,841	6,037	-59%
Baden-Württemberg	19,993	11,934	-40%
Bavaria	40,735	20,864	-49%
Saarland	1,634	1,024	-37%
Saxony-Anhalt	32,100	28,676	-11%
Brandenburg	45,832	27,732	-39%
Mecklenburg-Western Pomerania	36,271	13,993	-61%
Saxony	14,787	5,011	-66%
Thuringia	8,575	3,808	-56%
Arable farms	150,024	74,999	-50%
Dairy farms	23,506	16,220	-31%
Other grazing livestock farms	11,988	6,454	-46%
Pig & Poultry farms	12,914	9,449	-27%
Mixed farms	105,230	64,454	-39%
Permanent crops	2,158	869	-60%
Total	**305,820**	**172,445**	**-44%**

Source: Own calculations with FARMIS.

Figure 2. Profitability of eco-scheme 2 (diversified crop rotation)



Source: Own calculations.

easily adjust their crop rotation to the higher prices to grow wheat and rape rather that opt for eco-scheme 1a. Projected budget outlays for eco-scheme 1a decrease by 60 mill. €.

The profitability of eco-scheme 2 (diversified crop rotation) is displayed in figure 2 for both farms. To fulfil the requirements, legumes must be integrated into the crop rotation. On the typical farm in Brandenburg, peas replace rye on 10% of the arable land. For both price expectations this leads to a loss of 46 € gross margin II per hectare of the replaced crop. As legumes need to be grown on 10% of the arable land, this results into costs of 4.60 €/ha arable land. The gross margin differences are stable despite strong variation in nitrogen and output prices because the increase in revenue per hectare of rye is larger than for peas due to higher yield levels. This stronger increase offsets the increasing pre-crop value and nitrogen savings for peas. Therefore, eco-scheme 2 is profitable for both price scenarios on the farm in Brandenburg and leads to an additional profit of 25 €/ha arable land.

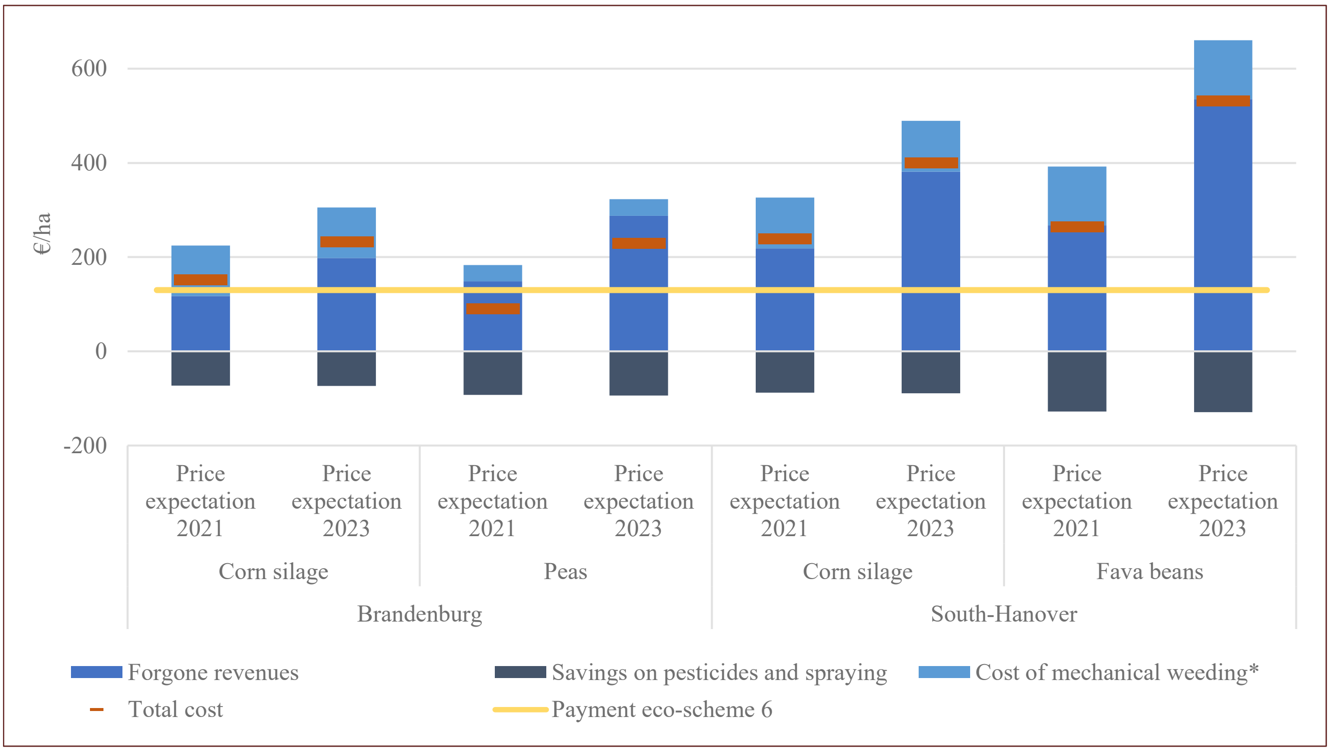
Due to a greater water supply, fava beans can be grown at the South-Hanoverian farm. Therefore, they replace wheat on 10% of the arable land. The difference in gross margin II per hectare of replaced wheat increases slightly (+42 €/ha) to 270 €/ha with the increased price expectations. This leads to costs of 27 €/ha arable land. Considering the payments of 30 €/ha, eco-scheme 2 can be implemented profitably on the South-Hanoverian farm. However, it is questionable whether farmers are willing to participate in an eco-scheme that offers a profit of less than 5 €/ha.

Moreover, eco-scheme 6 (crop management without pesticides) has been analysed. Figure 3 gives an overview of the profitability of eco-scheme 6 for both price scenarios.

On the typical farm in Brandenburg, it was profitable to renounce pesticides for peas with the historical price expectations as the additional costs for the forgone revenue (148 €/ha) and mechanical weeding (35 €/ha) were offset by the eco-scheme payment (130 €/ha) and savings for pesticide application (93 €/ha). For corn, the expected (93 €/ha). For corn, the expected yield and revenue losses were already too high. In any case, the new price expectations also make this option unprofitable as the forgone revenues for peas increase by 140 €/ha. Due to the higher yield level and forgone revenues, it is not economically viable to renounce the use of pesticides on the typical South-Hanoverian farm for either price scenario.

However, RÖDER et al. (2021b) point out that relative yield losses strongly depend on the weather and that losses differ quite strongly between the years. In some years with favourable dry weather conditions, it is possible to renounce pesticides in corn without any yield losses (INSTITUT FÜR PFLANZENSCHUTZ DER LFL BAYERN, 2012-2019). Thus, farmers might try to manage corn and peas without chemical pesticides at least in years with low price expectations and favourable dry weather conditions in the early spring.

Figure 3. Profitability of eco-scheme 6 (crop management without pesticides)



Note: * Corn: 1x weeding harrow (17.5 €/ha), 2x mechanical hoeing (45 €/ha); Peas: 2x weeding harrow; Fava beans: 3x weeding harrow, 2x mechanical hoeing.
Source: Own calculations.

Because the unprofitability of eco-scheme 6 is driven mainly by the uncertain assumption regarding the yield losses, we calculated the "break-even yield loss" for the typical farms. At this yield loss, the famers would be indifferent to participate in the eco-scheme. As Table 7 shows, the increased price expectations limit the acceptable yield losses strongly, especially for corn. While under the previous price assumptions the "break-even yield losses" of 12% for corn silage and 38% for peas were close to the assumed yield losses on the farm in Brandenburg, the price expectations for 2023 almost halve the acceptable yield losses. On the South-Hanoverian farm, the acceptable yield losses were already 50% below the assumed losses for the price expectations in 2021.

3.3 Economic Optimal Nitrogen Rate

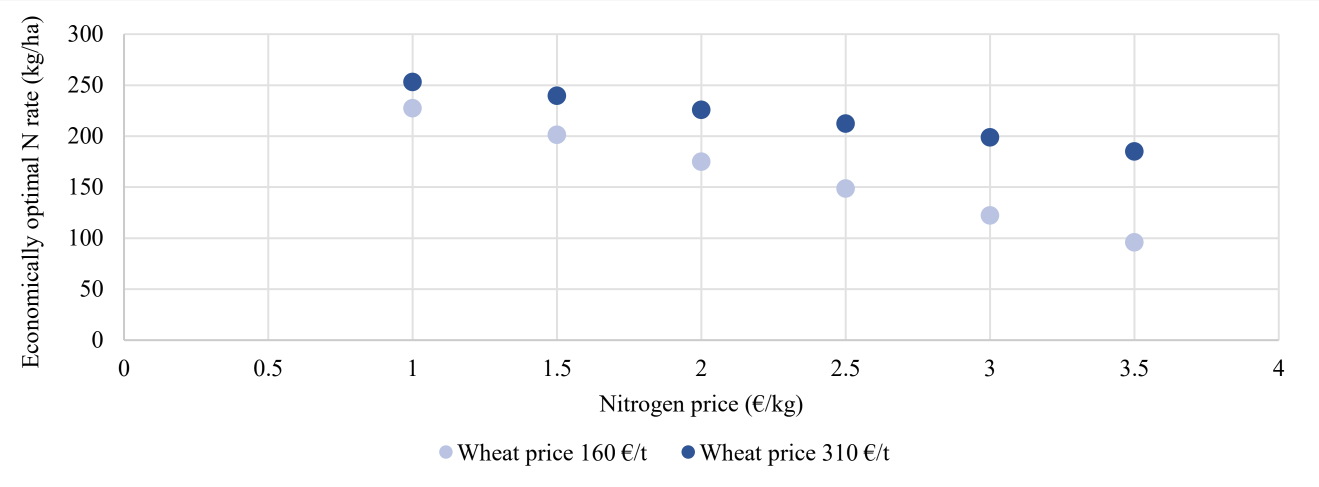
Figure 4 shows how the economically optimal nitrogen rate is influenced by increasing nitrogen prices for different wheat prices. At a wheat price of 160 €/t, the optimal nitrogen rate decreases by 30% (-70 kg/ha) if nitrogen prices rise from 0.8 €/kg to 2.2 €/kg, as assumed in Table 2. However, this potential decrease is, to a large extent, offset by the simultaneous increase of wheat prices to 310 €/t. At this price level, the economically optimal nitrogen rate increases again to 220 kg/ha, which is only 8% below the optimal rates at the previous price expectations. At this wheat price, an increase in nitrogen prices up to 3.5 €/kg, which could be caused by supply shortages of natural gas in Europe, would result in nitrogen reductions only in

Table 7. Assumed and break-even yield losses for eco-scheme 6

	Brandenburg				South-Hanover			
	Corn silage		Peas		Corn silage		Fava beans	
	Price expectation 2021	Price expectation 2023	Price expectation 2021	Price expectation 2023	Price expectation 2021	Price expectation 2023	Price expectation 2021	Price expectation 2023
Break-even yield loss	12%	7%	38%	20%	8%	4%	15%	8%
Assumed yield loss	15%		30%		15%		30%	

Source: Own calculations and RÖDER et al. (2021b).

Figure 4. Economic optimal N rate depending on wheat and nitrogen prices



Source: Own calculation.

the range of 20%. As described in chapter 2.4, we did not consider the impact of potential quality losses due to reduced nitrogen levels, which would further limit the economic viability of reducing nitrogen use. In comparison to our results, it has been shown that optimal nitrogen rates for wheat production in northern Germany can vary from year to year, between 135 and 220 kg/ha within a five-year period, due to changing weather conditions (HENKE et al., 2007). This also tends to confirm that a reduction in nitrogen intensity is unlikely. Beside our theoretical considerations regarding the optimal nitrogen rate, farmers would have to adapt their nitrogen fertilizer strategies if the overall physical availability of nitrogen fertilizer becomes an issue in the case of natural gas supply failures in Europe.

4 Discussion and Conclusion

We estimated the short-term impact of the Ukraine war on the income of German farmers for calendar year 2022. Our results indicate an increasing profitability for most farms as higher product prices overcompensate the increased input prices. Only for poultry farms is a war-related decrease in income calculated. It must be considered that the individual farm income situations can vary substantially from the mean values, as the individual timing of input purchases and product sales determine the profitability in volatile markets and we tend to underestimate the increase in sales and costs as we only considered price changes of outputs and inputs with reliable data regarding price developments. Furthermore, financial challenges can occur due to the time lag between input purchases and product sales. In this case, a liquidity programme with repayable loans can be an economically sensible approach to political aid. Against this background, the target of use of crises reserve remains unclear: if the intention is to counter sharp increases in input costs that may affect production and thus food security, direct subsidies to inputs may have been more effective (against the background of high uncertainty about product price developments). To address potential negative income effects, it would have been better to determine payment levels once incomes are known, and offer subsidies short-term, bridging credits to all farms.

Beside the economic effects, our results indicate that the increasing price levels are likely to have negative impacts on the environment. The main reason is that increasing margins in arable production go hand in hand with increasing opportunity costs for environmental services and lead to a decreasing willingness to participate, if the payments are not adapted. The increase of fertiliser prices only marginally influences the intensity level of nitrogen input as the increased product prices overcompensate the additional costs.

With increased price expectations and the envisaged payments for eco-schemes, only level 1 of eco-scheme 1 (increase non-productive land) remains profitable on the analysed typical farms. This will reduce the expected set-aside area by 150,000 ha. Compared with the previous environmental schemes of the second pillar, the newly introduced eco-schemes of the first pillar are binding for only one year, which allows farmers to react quickly to changes in short-term price expectations. This makes strong annual variations in participation possible or even likely, and the environmental contribution of the eco-schemes therefore will vary between years. This variation may negatively affect overall environmental benefit as effective biodiversity measures often require continuity in their implantation.

Annual varying participation also creates difficulties for budget planning and use. Currently unused budgets of different eco-schemes will be redistributed by a complex key which makes it almost impossible to estimate the final payments in advance. It can be expected that this additional uncertainty will further reduce the acceptance of eco-schemes in the farming community. Alternatively, policy makers could introduce a flexible mechanism to adjust payments to changing market expectations before winter crops are sown in autumn. Furthermore, our results show strong regional differences in the profitability of the eco-schemes are caused by differences in yield. These economic differences will increase with rising market prices and make it likely that eco-schemes will be implemented primarily in low yielding areas. One option to overcome this regional concentration could be to introduce different payment levels based on regional yield levels.

Literature

AGRARHEUTE (2022): Erzeugerpreise für Düngemittel. https://markt.agrarheute.com/duengemittel/, call: 16.6.2022.

AMI (2022): Preise für Getreide und Ölsaaten Jahre nach Monaten. https://www.ami-informiert.de/fileadmin/monitor/getpage/fuldl.php?file=Getreide_nachMonaten.xls&markt=getreide&art=monat, call: 27.6.2022.

BECKHOFE, A. (2022): Auch Nordzucker erwartet Rübenpreise von über 40 €/t. https://www.topagrar.com/markt/news/auch-nordzucker-erwartet-ruebenpreise-von-ueber-40-eur-t-13099032.html, call: 24.5.2022.

BMEL (Federal Ministry of Food and Agriculture) (2022): Vorräte an Getreide und Kartoffeln in der Landwirtschaft, MBT-0114060-0000. Statistische Monatsberichte, Bonn.

BRAUN, J. (2020): Weiterentwicklung eines sektorkonsistenten Betriebsgruppenmodells um Treibhausgasemissionen und Bewertung von ausgewählten Minderungsstrategien. Berliner Schriften zur Agrar- und Umweltökonomik, Issue 23. Shaker, Düren.

BULLOCK, D.G. and D.S. BULLOCK (1994): Quadratic and Quadratic-Plus-Plateau Models for Predicting Optimal Nitrogen Rate of Corn: A Comparison. In: Agronomy Journal 86 (1): 191-195.

CHIBANDA, C., K. AGETHEN, C. DEBLITZ, Y. ZIMMER, M.I. ALMADANI, H. GARMING, C. ROHLMANN, J. SCHÜTTE, P. THOBE, M. VERHAAGH, L. BEHRENDT, D. STAUB and T. LASNER (2020): The Typical Farm Approach and Its Application by the Agri Benchmark Network. In: Agriculture 10 (12): 646.

DEPPERMANN, A., H. GRETHE and F. OFFERMANN (2014): Distributional effects of CAP liberalisation on western German farm incomes. An ex-ante analysis. In: European Review of Agricultural Economics 41 (4): 605–626.

EHRMANN, M. (2017): Modellgestützte Analyse von Einkommens- und Umweltwirkungen auf Basis von Testbetriebsdaten. Thünen Report No. 48. Johann Heinrich von Thünen-Institut, Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei, Braunschweig. https://literatur.thuenen.de/digbib_extern/dn058604.pdf, call: 7.3.2018.

EUROPEAN COMMISSION (2022): Factsheet - a greener and fairer CAP. Brussels. https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/factsheet-newcap-environment-fairness_en.pdf, call: 9.7.2022.

GANDORFER, M., D. PANNELL and A. MEYER-AURICH (2011): Analyzing the effects of risk and uncertainty on optimal tillage and nitrogen fertilizer intensity for field crops in Germany. In: Agricultural Systems 104 (8): 615-622.

GLAUBEN, T., M. SVANIDZE, L. GÖTZ, S. PREHN, T.J. JAMALI, I. DURIĆ and L. KUHN (2022): The war in Ukraine exposes supply tensions on global agricultural markets: Openness to global trade is needed to cope with the crisis. IAMO Policy Brief 44, April 2022, Halle (Saale).

HENKE, J., G. BREUSTEDT, K. SIELING and H. KAGE (2007): Impact of uncertainty on the optimum nitrogen fertilization rate and agronomic, ecological and economic factors in an oilseed rape based crop rotation. In: The Journal of Agricultural Science 145 (5): 455-468.

HOWIND, K.-H. (2021): Düngung und Anbau 2022 Kurzfristig reagieren – langfristig planen. Online Seminar Ackerbauring, 30.11.2021, Online.

IGC (International Grains Council) (2022): Wheat and rapeseed future prices. https://www.igc.int/en/members-site/markets/igc_markets_Futures.aspx, call: 25.6.2022.

INSTITUT FÜR PFLANZENSCHUTZ DER LFL BAYERN (2012-2019): Versuchsberichte. Freising. https://www.lfl.bayern.de/ips/unkraut/032463/index.php, call: 9.7.2022.

KAGE, H., T. RÄBIGER and K. SIELING (2022): Stickstoffdüngung zu Winterraps und Winterweizen. Berichte über Landwirtschaft - Zeitschrift für Agrarpolitik und Landwirtschaft, aktuelle Beiträge.

KTBL (2020): Betriebsplanung Landwirtschaft 2020/21. Daten für die Betriebsplanung in der Landwirtschaft. KTBL-Datensammlung. Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL), Darmstadt.

LORENZ, F., A. BÜCHSE and K. ERDLE (2021): Versuchsergebnisse interpretieren. DLG kompakt 02/2021. https://www.dlg.org/fileadmin/downloads/landwirtschaft/themen/publikationen/kompakt/DLGKompakt_03_21.pdf, call: 14.7.2022.

LWK NIEDERSACHSEN (2022): Die neue GAP ab 2023 - eine ökonomische Optimierung der Anträge wird wichtiger! Webcode: 01039719. https://www.lwk-nieder sachsen.de/lwk/news/38437_Die_neue_GAP_ab_2023_-_eine_%C3%B6konomische_Optimierung_der_Antr%C3%A4ge_wird_wichtiger%21, call: 21.6.2022.

MEYER-AURICH, A. and Y.N. KARATAY (2019): Effects of uncertainty and farmers' risk aversion on optimal N fertilizer supply in wheat production in Germany. In: Agricultural Systems 173: 130-139.

MEYER-AURICH, A., A. WEERSINK, M. GANDORFER and P. WAGNER (2010): Optimal site-specific fertilization and harvesting strategies with respect to crop yield and quality response to nitrogen. In: Agricultural Systems 103 (7): 478-485.

NEHRING, K. (2011): Farm level implications of high commodity prices. An assessment of adaption strategies and potentials in selected regions in Australia and Germany. Landbauforschung Sonderheft 349, Braunschweig.

NIGON, T.J., C. YANG, D.J. MULLA and D.E. KAISER (2019): Computing uncertainty in the optimum nitrogen rate using a generalized cost function. In: Computers and Electronics in Agriculture 167: 105030.

NORDZUCKER (2022): Zuckerrüben-Lieferungsvertrag 2023/24. Braunschweig.

RÖDER, N., M. DEHLER, S. JUNGMANN, B. LAGGNER, H. NITSCH and F. OFFERMANN (2021a): Ausgestaltung der Ökoregelungen in Deutschland – Stellungnahmen für das BMEL. Band 1 – Abschätzung potenzieller ökologischer und ökonomischer Effekte auf Basis der Erstentwürfe. Thünen Working Paper. Johann Heinrich von Thünen-Institut, Braunschweig. https://www.thuenen.de/media/publikationen/thuenen-workingpaper/ThuenenWorkingPaper_180_Band_1.pdf, call: 6.4.2022.

RÖDER, N., M. DEHLER, B. LAGGNER, F. OFFERMANN, K. REITER, T. de WITTE and F. WÜSTEMANN (2021b): Ausgestaltung der Ökoregelungen in Deutschland - Stellungnahme für das BMEL. Band 2 - Schätzung der Inanspruchnahme der Regelungen auf Basis des Kabinettsentwurfes des GAPDZG. Thünen Working Paper 180 / 2. Johann Heinrich von Thünen-Institut, Braunschweig. https://www.thuenen.de/media/publikationen/thuenen-workingpaper/ThuenenWorkingPaper_180_Band_2.pdf, call: 22.6.2022.

TOP AGRAR ONLINE (2022): Milchwert. https://www.topagrar.com/markt/milch/milchwert-9814566.html, call: 6.6.2022.

WIDDEL, R. (2022): Expert assessment on input price developments for harvest 2023. Verbal communication.

Contact author:
RAPHAELA ELLßEL
Thünen Institute of Farm Economics
Bundesallee 63, 38116 Braunschweig
e-mail: raphaela.ellssel@thuenen.de