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Drivers of farm performance in Czech crop farms

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Electronic supplementary material (ESM)

Supplementary Material S1

Supplementary Tables S1–S3

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Supplementary Material S1

The unbalanced panel data was taken from the FADN (2018) for the period 2005–2017. Descriptive statistics of Czech crop farms, full sample (1st and final year) is in Table S1 (ESM).
Descriptive statistics of the three estimated crop farm classes is in Table S2 (ESM).
Full Production Function Estimate (Separate SFA-TRE model) for each class and for all farms is in Table S3 (ESM).

True random effects model (TRE) variables

y	Crops output	SE135_I10
x_1	Land	SE025 UAA (ha)
x_2	Labour	SE010 AWU
x_3	Capital	SE436 – SE485 + SE350_I10 + SE360
		SE436 Total assets
		SE485 Total liabilities
		SE350_I10 Inputs for Services (I10)
		SE360 Depreciation
x_4	Materials	SE275_I10 – SE310_I10 – SE330_I10 – SE345_I10 – SE300_I10
		SE275_I10 Intermediate consumption (I10)
		SE310_I10 Feed for grazing livestock (I10)
		SE330_I10 Other Livestock Inputs (I10)
x_5	Chemicals	SE300_I10 Crop protection (I10)

Inefficiency variables

Altitude	Altitude (1: < 300m, 2: 300–600m, 3: > 600m)
LFA	LFA category (1: non LFA, 2:other than mountain, 3: mountain areas)
FormOfOwnership	Form ownership category (1: self-employment, 2: legal person, 3: cooperative form)
dInvstSubs	Investment subsidies dummy (0/1)
dAEOsubs	AEO subsidies dummy (0/1)
dLFAsubs	LFA subsidies dummy (0/1)
dChemie	Crop protection dummy (0/1)
dfh_labor	Unpaid labour dummy (0/1)
dES	Economic size category [1 = 3, ..., 4; 2 = 6, ..., 8; 3 = 9, ..., 11; 4 = 12, ..., 14]
gUAA	UAA group (1 = 4, ..., 83.9; 2 = 84, ..., 195; 3 = 195.1, ..., 619.9; 4 = 620, ..., 6 842)
gAEOha	Environmental subsidies per ha group (1, 2, 3, 4)
gLFAha	LFA subsidies per ha group (1, 2, 3, 4)
gIO	Material costs Crop production ratio group (1, 2, 3, 4)
dAge	Age (years) group (1 = 18, ..., 35; 2 = 36, …, 53; 3 = 54, ..., 71; 4 = 72, ..., 87)

Other inefficiency variables tested (but not used)

gLUha	Livestock units per hectare group
Education	Education (1: primary, 2: secondary, 3: high)
dOrganic	Organic farming dummy (0/1)
Organic	Organic farming category (1, 2, 3, 4)
gAWU	AWU group (1, 2, 3, 4)
gAWUha	AWU per ha group (1, 2, 3, 4)
UAArent	Share land rented group (1, 2, 3, 4)
gCapital_lb	Capital/labour ratio group (1, 2, 3, 4)

Input variables were normalised so obtained parameters can be considered as output elasticities evaluated at the geometric mean of the sample. The signs of the elasticity of land, labour, capital, materials and chemicals met expectations; that is, all of them were positive (i.e. x_1, x_2, x_3, x_4, x_5 variables).

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Class 1. The first-order estimated parameters are significant at 1% level of significance under *z*-test except the variable representing Labour and Capital, that is significant at 10% level. The assumption of monotonicity and quasi-concavity is fulfilled for all production factors, except Material. Since the values of production factors were normalised by their arithmetic means after logarithmic transformation. in trans logarithmic model these coefficients denote the variation or possible percentage change in aggregate output as the result of one percent change in the input, that is, production elasticity. All production elasticities are positive; the highest elasticity displays production factor Land (0.349). The production factor Capital, in opposite, has low impact on firms' output (0.065). The parameter λ is the relation between the variance of $\boldsymbol{u}_{it}$ and $\boldsymbol{v}_{it}$. Thus, the parameter indicates the significance of technical inefficiency in the residual variation. A value larger than one suggests that variation in $\boldsymbol{u}_{it}$ prevails the variation in the random component $\boldsymbol{v}_{it}$. In the case of Class 1 farms the parameter is close to one. Technical change has positive impact on production. It is characterised by Material-saving, and Land-, Capital-, Labour- and Chemicals-intensive behaviour.

Farm altitude positively contribute to the variance of technical inefficiency (i.e. increase the variance of technical inefficiency) at 10% level of significance. That is, the higher farm's altitude, the higher its technical inefficiency variance. Farms, recipients of subsidies on investments have lower variance of technical inefficiency. The higher share of material input on total crop production increases technical inefficiency variance.

Class 2. The parameters of the model are statistically significant at 1% level of significance. The slopes of the coefficients are positive, that is consistent with economic theory. The highest elasticity belongs to production factor Material (0.441). The other factors have lower impact on production output (0.112 for Labour and 0.062 for Capital). Estimated parameters of production factors satisfy the curvature assumption of quasi-concavity in inputs, except Land variable. Technical change is characterised by positive impact on production, and Capital-, Material-, Chemicals-saving, but Land- and Labour-intensive features.

Among the factors that were incorporated to the variance of technical inefficiency component, there are several that have significant impact on it. AEO subsidies increase technical inefficiency variance, whereas economic size category, in opposite, decrease. The higher share of material input on total crop production decreases technical inefficiency variance.

Class 3. The criteria of theoretical consistency, i.e. the assumptions regarding positive slope of the production function (monotonicity), and curvature assumption (quasi-concavity in inputs) are fulfilled in the case of all production factors, except Land. Elasticity of the production factor Labour is the lowest among other production factors (0.058). Material has the highest impact on production with the value of 0.459. The parameter λ indicates the significance of inefficiency term in the residual variation. The sector is characterised by positive and significant impact of technical change, where Capital-, Material- and Chemicals are of saving, and Land- and Labour- are of intensive-using behaviour.

Farm attitude, form of ownership, Agri-environmental and LFA (less favourable area) subsidies increase variance of technical inefficiency component.

All classes. Monotonicity assumption is fulfilled for all production factors. Quasi-concavity (diminishing marginal productivity) assumption is not fulfilled for the production factor Land. First-order parameters are significant at 1% level of significance. Production factor Material has the highest elasticity (0.428), whereas the elasticity of Capital is 0.090. The parameter λ is more than one indicates the importance of an inefficiency effect compared to statistical noise. The parameter β_T is positive and supposes negative impact of technical change on production output. It is characterised by Land-, Labour-, Chemicals-intensive, and Capital- and Material-saving behaviour.

Farm altitude, form of ownership and Agri-Environmental subsidies variable increase the variance of technical inefficiency. Farms economic size and farmers age contribute to decreasing of technical inefficiency variance.

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Table S1. Descriptive statistics, Czech crop farms

	Full sample (n = 4 429)	1st year (2005; n = 215)	Final year (2017; n = 320)
Statistical measure	mean	mean	mean
Variable[1]	[min; max]	[min; max]	[min; max]
Crops output (EUR)[2]	578 954.9 [833.2; 9 157 567]	263 741.7 [3 577.25; 1 724 662]	726 624.5 [14 148.9; 8 373 163]
Land (ha)	460.0847 [4.59; 6 842.23]	537.1202 [19.93; 5 376.48]	514.3077 [12.41; 6 719.6]
Labour (AWU)	9.77837 [0.35; 178.03]	13.92967 [0.74; 125.83]	9.790563 [0.46; 112.11]
Total assets (EUR)	1 227 405 [14 652; 18 100 000]	1 214 008 [32 433; 12 600 000]	1 492 164 [15 383.45; 16 600 000]
Total liabilities (EUR)	303 174 [0; 5 703 878]	316 744.5 [0; 3 450 880]	424 309.1 [0; 5 703 878]
Inputs for services (EUR)[2]	29 508.1 [0; 1 029 030]	31 318.66 [0; 502 369.9]	30 721.74 [0; 562 037.1]
Depreciation (EUR)	62 551 [0; 1 228 359]	47 215.45 [238.92; 486 234.2]	84 950.29 [0; 1 228 359]
Intermediate consumption (EUR)[2]	437 832.4 [4 137.45; 6 318 823]	327 373.7 [4 137.45; 2 615 128]	537 058.1 [8 753.69; 6 200 247]
Feed for grazing livestock (EUR)[2]	19 868.88 [0; 1 178 927]	27 766.32 [0; 486 056.3]	15 889.18 [0; 1 178 927]
Other livestock inputs (EUR)[2]	5 667 [0; 1 532 573]	9 766.437 [0; 218 243.4]	4 373.049 [0; 291 904.9]
Crop protection (EUR)[2]	60 575.32 [0; 1 161 106]	44 793.23 [0; 542 422.5]	81 852.53 [1 351.373; 1 161 106]
Labour input (hours)	19 993.45 [700; 362 887]	28 807.6 [1 500; 272 716]	20 109.07 [900; 224 350]
Unpaid labour input (hours)	2 728.902 [0; 31 800]	27 61.712 [0; 16 850]	2 361.106 [0; 16 100]
dOrganic (0–1 probabilities)	0.020998 [0; 1]	0.027907 [0; 1]	0 [0; 0]
Age (years)	50.80244 [18; 86]	48.57209 [26; 78]	53.6375 [20; 77]
LFA (1, 2, 3)	1.181305 [1; 3]	1.274419 [1; 3]	1.18125 [1; 3]

[1]Values per year

[2]Defalted values (100 = 2010) (http://ec.europa.eu/agriculture/rica/infometa_en.cfm)

Source: Authors' calculations based on the FADN CZ 2005–2017 data (FADN CZ Database 2018)

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Table S2. Descriptive statistics by class, Czech crop farms

	Class 1	Class 2	Class 3
x_1 Land – SE025 UAA (ha)	220.9	196.1	1 191.5
x_2 Labour – SE010 AWU	3.3	2.9	29.0
SE011 Labour input (total in hours)	7 318.5	6 004.1	58 753.1
SE016 Total unpaid labour input in hours	4 391.3	3 459.4	164.6
dOrganic (1/0)	0.02	0.01	0.04
Age	49.3	49.8	54.0
LFA (1, 2, 3)	2.1	1	1.1
y SE135 Crops output (I10)	193 222	217 647.3	1 611 540
SE436 Total assets	414 142.4	400 669.6	3 552 679
SE485 Total liabilities	75 818.4	68 869.7	960 486.8
SE350 Inputs for services (I10)	6 222.6	8 580.7	89 826.2
SE360 Depreciation	27 210.6	25 030.4	167 234.9
SE275 Intermediate consumption (I10)	129 364.6	141 312.8	1 280 886
SE310 Feed for grazing livestock (I10)	7 632.0	1 869.9	67 538.8
SE330 Other Livestock inputs (I10)	1 125.4	518.9	19 864.4
x_5 Chemicals – SE300 Crop protection (I10)	21 571.2	25 184.2	162 379.2

x_3 – Capital (SE436 – SE485 + SE350_I10 + SE360); x_4 – Materials (SE275_I10 – SE310_I10 – SE330_I10 – SE345_I10 – SE300_I10)
Source: Authors' calculations based on the FADN CZ 2005–2017 data (FADN CZ Database 2018)

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Table S3. Czech crop farms – full production function estimates (true random effects panel translog model per class; 2005–2017)

Variables	Class 1	Class 2	Class 3	All
	Frontier	Frontier	Frontier	Frontier
x_1	0.349***	0.240***	0.0800**	0.257***
	(0.0678)	(0.0265)	(0.0378)	(0.0256)
x_2	0.0950*	0.112***	0.0581**	0.0973***
	(0.0528)	(0.0250)	(0.0286)	(0.0207)
x_3	0.0650*	0.0622***	0.137***	0.0895***
	(0.0353)	(0.0150)	(0.0245)	(0.0139)
x_4	0.258***	0.441***	0.459***	0.428***
	(0.0613)	(0.0263)	(0.0412)	(0.0265)
x_5	0.254***	0.195***	0.231***	0.122***
	(0.0469)	(0.0254)	(0.0384)	(0.0198)
t	0.0375***	0.0360***	0.0232***	0.0327***
	(0.00475)	(0.00198)	(0.00216)	(0.00179)
x_{11}	0.0821	0.328***	0.534***	0.256***
	(0.207)	(0.0817)	(0.0905)	(0.0479)
x_{22}	–0.0749	0.0805	0.0191	–0.00425
	(0.0992)	(0.0658)	(0.0290)	(0.0338)
x_{33}	0.0265	–0.0149	0.0352	–0.00880
	(0.0743)	(0.0201)	(0.0472)	(0.0167)
x_{44}	0.337	0.136**	–0.260***	0.0658
	(0.263)	(0.0544)	(0.0924)	(0.0669)
x_{55}	0.0356***	0.0261***	0.0365***	0.0168***
	(0.00770)	(0.00407)	(0.00668)	(0.00308)
tt	–0.0182***	–0.0132***	–0.0131***	–0.0164***
	(0.00226)	(0.000995)	(0.00135)	(0.000864)
x_1x_2	0.164	–0.178***	–0.221***	–0.163***
	(0.127)	(0.0569)	(0.0592)	(0.0453)
x_1x_3	–0.0895	–0.0199	0.0450	0.0163
	(0.107)	(0.0346)	(0.0639)	(0.0316)
x_1x_4	–0.278	–0.0694	–0.0897	–0.0806*
	(0.198)	(0.0581)	(0.0616)	(0.0479)
x_1x_5	0.00156	–0.118**	–0.187***	–0.0562*
	(0.0344)	(0.0514)	(0.0608)	(0.0307)
x_2x_3	–0.0221	0.0602	0.0170	0.0542**
	(0.0728)	(0.0372)	(0.0378)	(0.0259)
x_2x_4	–0.0457	0.0116	0.131***	0.0557
	(0.0966)	(0.0429)	(0.0472)	(0.0392)
x_2x_5	–0.0197	0.0140	0.00755	0.00182
	(0.0247)	(0.0325)	(0.0528)	(0.00840)
x_3x_4	0.0963	–0.0871**	–0.0303	–0.0596*
	(0.0985)	(0.0431)	(0.0389)	(0.0341)

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Table S3 to be continued

Variables	Class 1	Class 2	Class 3	All
	Frontier	Frontier	Frontier	Frontier
x_3x_5	0.0154	0.110***	–0.0486	0.0221
	(0.0363)	(0.0372)	(0.0383)	(0.0222)
x_4x_5	–0.0136	–0.0172	0.161**	0.0241*
	(0.0242)	(0.0270)	(0.0710)	(0.0124)
x_{1t}	0.0373***	0.0131***	0.0250***	0.0173***
	(0.0119)	(0.00502)	(0.00610)	(0.00346)
x_{2t}	0.00122	0.00275	0.0163***	0.00538*
	(0.0100)	(0.00442)	(0.00497)	(0.00292)
x_{3t}	0.00651	–0.000971	–0.0129***	–0.00306
	(0.00761)	(0.00384)	(0.00491)	(0.00296)
x_{4t}	–0.0415***	–0.00413	–0.00938*	–0.0178***
	(0.0140)	(0.00535)	(0.00523)	(0.00378)
x_{5t}	0.00109	–0.00746*	–0.0135**	0.000306
	(0.00275)	(0.00408)	(0.00538)	(0.00109)
Constant	0.300***	0.216***	0.281***	0.301***
	(0.0362)	(0.0168)	(0.0209)	(0.0203)
Inefficiency variables				
Altitude	0.887*	0.0528	0.675***	0.430***
	(0.518)	(0.156)	(0.243)	(0.135)
LFA	0.691	–	0.0741	–0.109
	(0.853)	–	(0.334)	(0.134)
FormOfOwnership	0.542	0.0950	0.511**	0.316**
	(1.297)	(0.290)	(0.204)	(0.144)
dInvstSubs	–0.724**	0.318	0.00619	–0.110
	(0.346)	(0.458)	(0.238)	(0.255)
dAEOsubs	0.404	0.335**	–	0.451***
	(0.419)	(0.149)	–	(0.110)
dLFAsubs	0.0301	–0.250	–	–0.0233
	(0.430)	(0.296)	–	(0.180)
dES	–0.620	–1.229***	–	–0.779***
	(0.461)	(0.180)	–	(0.129)
gUAA	–0.00754	0.117	–	1.092***
	(0.308)	(0.112)	–	(0.180)
gAEOha	0.609	–	0.345***	–
	(0.379)	–	(0.101)	–
gLUha	–0.306	–0.232	–	–
	(0.229)	(0.176)	–	–
gLFAha	–0.741	–	1.137**	–
	(0.527)	–	(0.553)	–
gIO	1.980***	2.015***	–	–
	(0.157)	(0.106)	–	–

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Table S3 to be continued

Variables	Class 1	Class 2	Class 3	All
	Frontier	Frontier	Frontier	Frontier
dAge	–	–	–	–0.141*
	–	–	–	(0.0832)
dChemie	–	–	–1.001	0.0359
	–	–	(0.977)	(0.832)
gES	–	–	–	–1.354***
	–	–	–	(0.177)
Observations	626	2 644	1 159	4 429
Number of farms	111	344	145	506

Robust standard errors in parentheses ***$P < 0.01$;** $P < 0.05$; * $P < 0.1$

The importance of an inefficiency effect compared to statistical noise [λ]: Class 1 = 0.92, Class 2 = 0.801, Class 3 = 1.552, all observations = 1.09

Source: Authors' calculations based on the FADN CZ 2005–2017 data (FADN CZ Database 2018)