OECD 21st FLA

„Drivers of Farm Performance - Country Case Studies using an Empirical Approach“

Draft Report

Oslo 5/6/18

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1 intro

- FLA network project running from 1 Sep 17 - 30 Nov 18
- links to previous projects in the network on tfp measurement, innovation activities and farm clustering
- project aims
  - analyse correlations between farm characteristics and farm performances,
  - more accurately predict farm responses to policy measures
- empirical evidence to optimise sustainable productivity growth at farm level
  - identifying and measuring structures and patterns,
  - considering significant correlations and contextual settings wrt technology, organisation, environment, location, socioeconomics, policy framework etc.
- cross-country perspective
- focus on different sectors

1 intro

- 1st project phase
  - Estonia, Czech Republic (dairy) - Hungary, Italy (crops)
  - specifications and estimation of different technologies
  - farm class identification
- 2nd project phase
  - countries: France, Korea, Norway, Denmark, Chile
  - ongoing interest: UK, NL, Ireland and Switzerland
  - additional analytics: dynamics in technology, policy responses

1 intro

- performance measurement at farm level
  - various dimensions, different measures, total vs. partial perspective
  - here: econometric production function based farm productivity measure
- structural, process related and behavioural factors for performance
  - production structure: e.g. labor, farm size
  - access to resources and technologies: natural, infrastructure, extension etc.
  - agro-ecological conditions and climate dynamics: soil, precipitation, biodiversity
  - location: market access, policy framework, network effects
  - unforeseen events: pests, diseases, natural disasters
  - individual abilities: experience, education, age, peer-group interaction

1 intro

- in reality: different production technologies or production systems with varying technical change patterns
- consideration of these differences is at core of effective and efficient policies
- over time: evolvement of new technologies or systems (continuum or discrete shock)
- farm categorization often depends on research/policy interest

- robust methods for systematic classification of farms based on multidimensional vector of characteristics
  - discrete indicator, sub-samples, cluster analysis, random coefficient estimation, latent-class estimation (technology and categories/classes)

2 analysis

.. applied method(s)

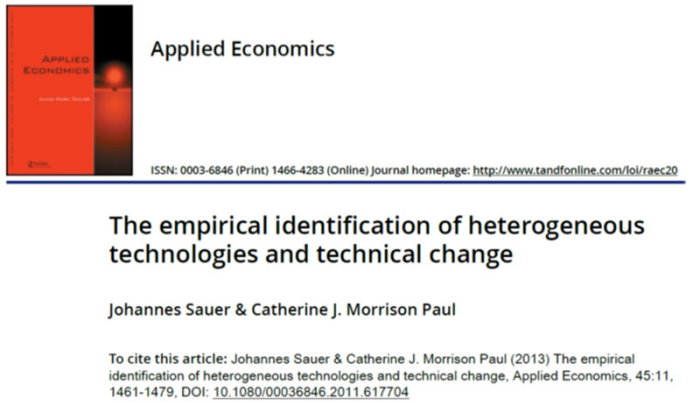
index based <u>simultaneous estimation</u> of technology and farm clusters

. multi-dimensional indeces based on standardized deviations

. well-defined 2nd order functional form

. latent-class estimation

. panel features



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The empirical identification of heterogeneous technologies and technical change

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2 analysis

step I define and measure indices

index 01 - structure

[family labor, hired/family labor, farms size land, ownership]

$$i01_i = (flabor_i - flabor_j)*w_{lab} + (1-(size_i - size_j))*w_s + (own_i - own_j)*w_o$$

index 02 - sustainability

[chemicals per ha, organic, environmental subsidies, agri-env participation]

$$i02_i = (1-(chem\ per\ ha_i - chem\ per\ ha_j))*w_{chem} + (organic_i - organic_j)*w_{org} + (envsubs_i - env\ subs_j)*w_{es}$$

2 analysis

step I define and measure indices..

index 03 - innovation/commercialisation/cooperation

[net investment, investm ratio, share land rented, biofuel production, cooperation]

index 04 - technology

[labor per ha, materials/interm per ha, depreciation/capital per ha, labor per depr/cap, total assets]

index 05 - diversity

[Herfindahl index, livestock prod, other output prod, (labor per output, materials per output)]

index 06 - individual

[age, off-farm work]

index 07 - location/environmental conditions

[less favoured area, altitude, nature2000, nitrate sensitive zone]

2 analysis

Table 1. Indexes for farm classification

Components for multi-dimensional indices as elements of class identification vector q, see equation [3].

Indexes / Components	Index 1 Structure	Index 2 Sustainability	Index 3 Innovation/ Commerce/Coop	Index 4 Intensity	Index 5 Diversity	Index 6 Individual	Index 7 Location
Acreage	x						
Age						x	
Agritourism income			x				
Altitude							x
Biofuel income			x				
Capital per cow				x			
Capital per labour				x			
Chemicals usage		x					
Education						x	
Environmental subsidies		x					
Experience						x	
Family labour share	x						
Forestry production					x		
Gender						x	
Herd size	x						
Herfindahl index					x		
Investment subsidies			x				
Labour per cow				x			
Land irrigated share			x				
Land rented share			x				
Less-favoured-area							x
Material per land				x			
Natura2000							x
Net investment ratio			x				
Organic production		x					
Ownership	x						
Production diversity					x		
Stocking density		x					
Total assets				x			

Note: Final choice of indices' components depends on production type and data availability.

2 analysis

step II run PCA to calculate index scores

- a **PCA** is run for each farm related dimension (e.g. production structure, sustainability etc.)
- the **eigenvalue** for each component represents how much of variance the component explains (i.e. factor loading), the **factor loadings** are used to **calculate the index score**
- up to seven **different farm indices** are defined and estimated for each observation of the respective sample using the **deviations of each index component** from the sample mean
- scaling issues between different components (e.g. share of family labour versus herd size or acreage) are further addressed by calculating the **z-score based deviations** for these component

+ statistical quality checks

- significance and **posterior probabilities of resulting q-variable coefficient's estimates** are evaluated for the individual farm classes
- **statistical tests** are applied to robustly determine the number of classes (for example, the Akaike Information Criterion/Schwarz and Bayesian information criterion [AIC/SBIC] tests by testing down)

2 analysis

step III estimate technologies and classes

$$Y_{it|c} = \alpha_0 + \sum_{k=1}^{n} \beta_{k,c} lnx_{kit} + \frac{1}{2}\sum_{k=1}^{n} \beta_{kk,c} lnX_{kit} lnX_{kit} + \sum_{k=1}^{n-1}\sum_{l=k+1}^{n} \gamma_{kl,c} lnx_{kit} lnx_{lit}$$
$$+\delta_{T,c} t_{it} + \delta_{TT,c} t_{it} t_{it} + \sum_{k=1}^{n} \delta_{kT,c} lnx_{kit} t_{it} + \varepsilon_{it|c}$$

$$P_{ic} = exp(\theta_c q_i) \Big/ \left[\sum_{c} exp(\theta_c q_i)\right]$$

i – farm

t – year

c – group/cluster

q – drivers/characteristics/indices =

[i01, i02, i03, i04, i05, i06, i07]

2 analysis

step IV estimate productivity level per/across class(es)

parameterised production function, Wald test formula, Delphi method at sample means

step V estimate technical change per/across class(es)

parameterised 1st derivative (dy/dt), Wald test formula, Delphi method at sample means

step VI estimate elasticities and scale economies per class

parameterised 1st derivatives (dy/dx), Wald test formula, Delphi method at sample means

step VII descriptives per class

3 empirical cases - 1st phase

- Estonia
  - data: farm level data 2000-2015, dairy
  - farms: 1056
  - observations: 2935
  - average years in sample: 9.8
- Hungary
  - data: farm level data 2001-2014, crops
  - farms: 2937
  - observations: 14128
  - average years in sample: 9.4
- Italy
  - data: farm level data 2008-2015, crops
  - farms: 7239
  - observations: 20847
  - average years in sample: 2.9
- Czech Republic
  - data: farm level data 2005-2015, dairy
  - farms: 156
  - observations: 1011
  - average years in sample: 8

4 results‘ summary

- Estonia
  - 2 classes
  - both positive technical change
  - significant productivity difference

- Hungary
  - 3 classes
  - one class relatively low productivity
  - significant technical change

- Italy
  - 3 classes
  - slightly negative technical change for one class

- Czech Republic
  - 3 classes
  - significant prod differences
  - high productivity and technical change correlated

4 preliminary results - 1st phase

Estonia

.. productivity & technical change

Table 6. Characteristics of Estonian dairy farms by class
Latent Class Estimation, Panel 2000 to 2015

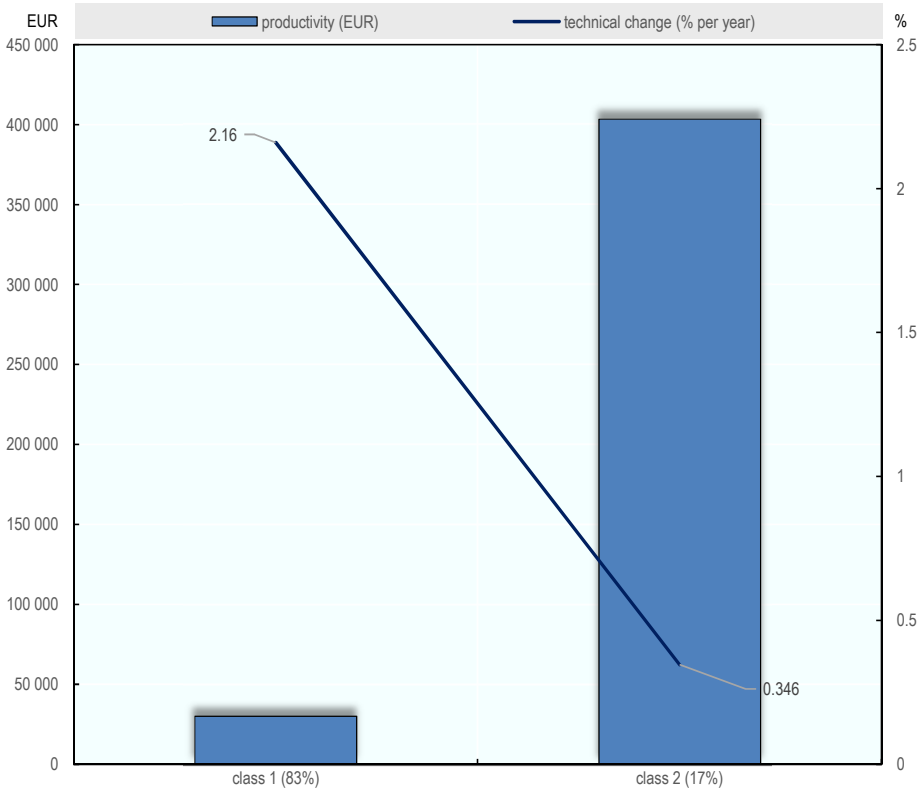
	Class I	Class II
Number of observations (% of sample farms)	2 431 observations (83%)	504 observations (17%)
Prior probability of class membership	0.4922	0.5008
Posterior probability of class membership	0.8252	0.1748
Productivity level (EUR per year) [1]		
- Class I Technology	30 055.5*** [2]	301 130.8***
- Class II Technology	126 033.2***	403 406.5***
Technical Change (% per year)		
- Class I Technology	2.16***	0.699***
- Class II Technology	0.271***	0.346***

Note: 1. Fitted values at sample means, 2- * significant at 10%, ** significant at 5%, *** significant at 1%.

4 results

Estonia

Figure 1. Productivity and technical change for Estonian dairy farms, by class, 2000 to 2015



Source: Estimations

4 results

Estonia

2 distinct classes of dairy farms

- uneven distribution
- class #1 largest
- nearly all dimensions (indices) are significantly important for identification
- highly significant production functions
- significant productivity differences between classes
- technical change significantly varies between classes
- increasing returns to scale for both classes, slightly lower for class #2 (17%)
- switching technologies could result in higher productivity but lower technical change for most farms (and vice versa)

4 results

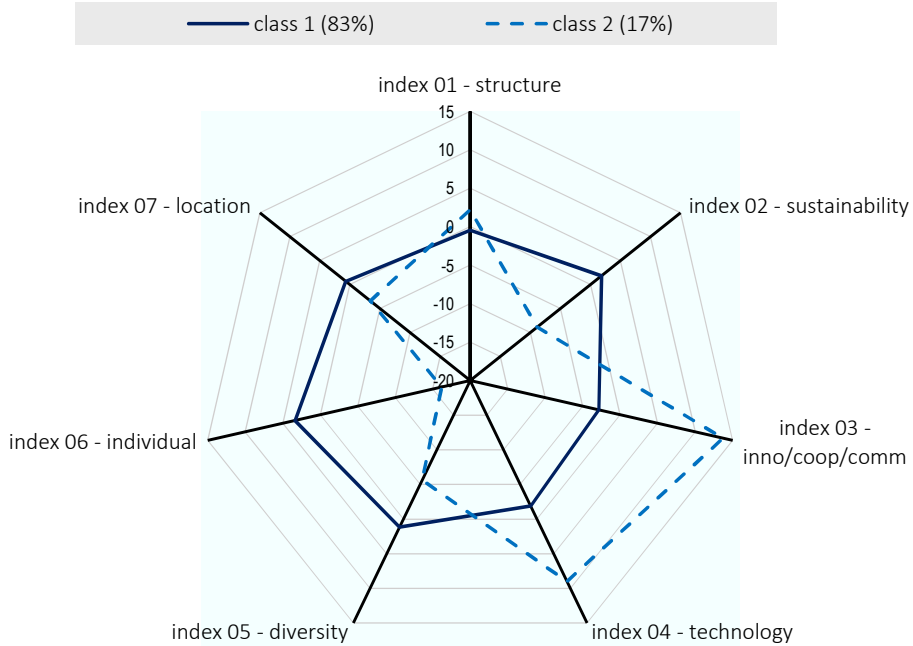
Estonia

Table 7. Class identification - mean values indices, Estonian dairy farms
Mean values[1]

	Class I	Class II
Index 1 - Structure	-0.4595	2.2165
Index 2 - Sustainability	1.8418	-8.8839
Index 3 - Innovation/Cooperation/Commercialisation	-2.8488	13.7411
Index 4 - Technology	-1.8691	9.0153
Index 5 - Diversity	1.1648	-5.6182
Index 6 - Individual	3.3621	-16.2166
Index 7 - Location	0.7012	-3.3821

Note: 1- at class means, scaled values.
Source: Estimations.

Figure 2. Indices for Estonian dairy farms
Scaled values at class means, 2000 to 2015



Source: Estimations.

4 results

Estonia

Table 8. Descriptive statistics by class, Estonian dairy farms
Deviations from sample means[1]

	Class I (n = 2431)	Class II (n = 504)
Production structure		
Hired / family labour ratio	-0.2177	1.0501
Herd size (livestock units)	-64.2584	309.9446
Land (ha)	-201.4147	971.506
Sustainability		
Stocking density (livestock units/ha)	-0.0514	0.2478
Chemicals usage (EUR per ha)	-302.4744	33.2247
Organic (probability)	0.0224	-0.1082
Innovation / Commercialisation		
Net investment ratio (per total assets)	-0.7852	0.1603
Cooperation (probability)	-0.1332	0.6424
Technology		
Capital / labour ratio (EUR per hour)	-1.9849	9.5742
Capital / cow ratio (EUR per cow)	-169.043	815.3643
Diversity		
Herfindahl Index (sqrt[Σ(yi/Y)2])	-0.0017	0.0084
Fodder / cow ratio (EUR per cow)	0.0292	-0.1406
Labour per cow ratio (hour per livestock unit)	-0.0533	0.2569
Individual		
Age (years)	0.3362	-1.6217
Location		
Less Favoured Area (probability)	0.0074	-0.0356
Natura 2000 (probability)	0.0001	-0.0006

Note: 1. Deviations from sample means (= 0), scaled values.
Source: Estimations.

4 results

Estonia

class #1

- less productive farms but most significant technical change
- high share of family labor
- below average herd and acreage size (significant irts)
- high score on sustainability (based on indicators)
- lower investment rate and lower than average prob for cooperation
- lower than average capital intensity, higher fodder intensity
- more diversified farms (HI)
- bit older than average farmers
- more likely to be located in less-favored areas and n2000

4 results

Estonia

class #2

- highly productive farms but low technical change
- hired labor is essential (ratio>1)
- significantly above average herd and acreage size (still irts)
- lower than average score on sustainability (based on indicators)
- high investment rate and probability for cooperation
- higher than average capital intensity, but also more labor per cow
- more specialised farms (HI)
- younger than average farmers
- less likely to be located in less-favored areas and n2000

4 results

Estonia

summary

- dairy farms‘ performances depend on a multitude of factors (structural, behavioural and external)
- within the dairy sector distinct classes of farms can be identified along a multi-dimensional scale
- these classes significantly vary with respect to their economic performance and their technical development over time
- innovative dairy farms are likely to be also more productive, here: a strong correlation
- family driven and smaller farms show higher sustainability (cl1)
- highly sustainable dairy farms are most likely located in less-favored areas (cl1)
- capital intensity and degree of specialisation is positively correlated with herd size (cl2)
- dairy farm productivity is correlated with herd size and hired labor share (cl2)
- more sustainable dairy farms also show to be less productive (cl1)

4 results

Hungary

.. productivity & technical change

Table 9. Characteristics of Hungarian crop farms, by class
Latent Class Estimation, Panel 2001 to 2014

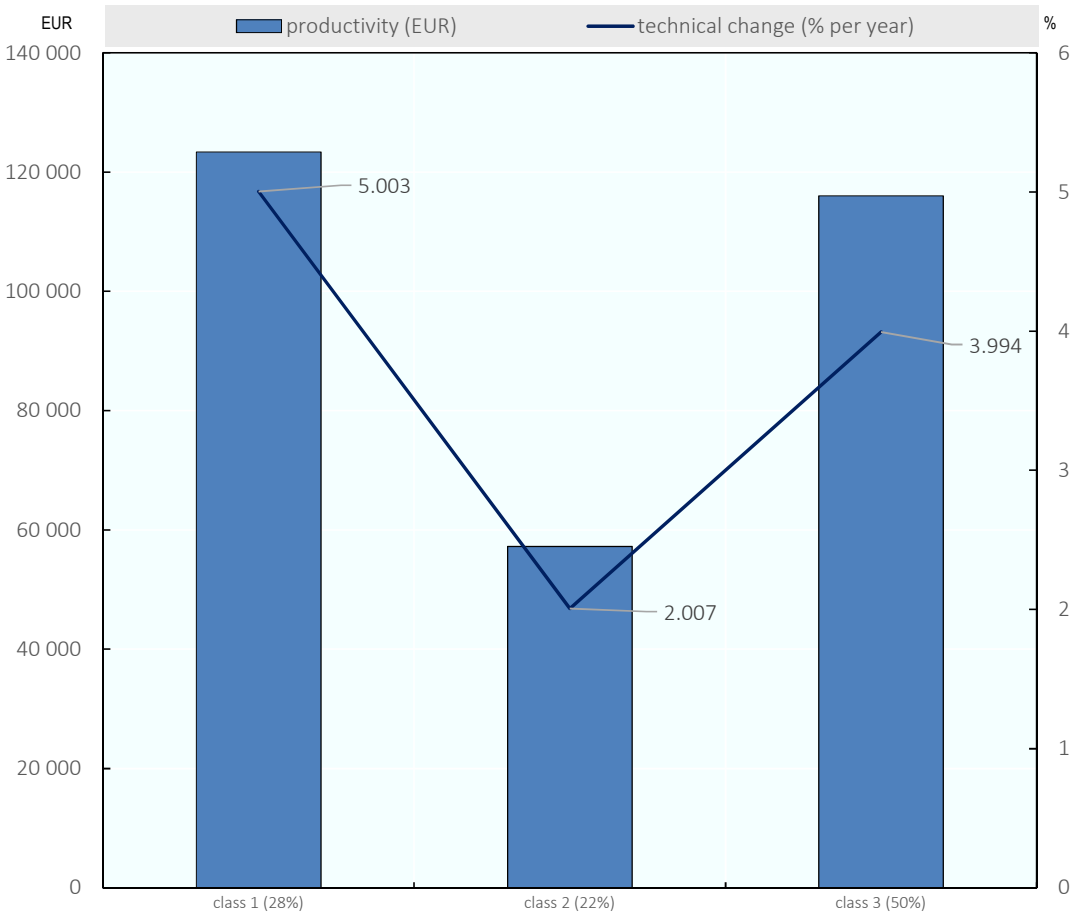
	Class I	Class II	Class III
Number of observations (% of sample farms)	3933 obs. (28%)	3057 obs. (22%)	7138 obs. (50%)
Prior probability of class membership	0.2672	0.2592	0.4736
Posterior probability of class membership	0.2978	0.2379	0.4643
Productivity level (EUR per year) [1]			
- Class I Technology	123 355.1*** [2]	86 130.6***	145 702.3***
- Class II Technology	83 118.3***	57 234.3***	101 145.9***
- Class III Technology	94 458.8***	64 813.5***	116 020.6***
Technical Change (% per year)			
- Class I Technology	5.003***	4.987***	5.157***
- Class II Technology	2.246***	2.007***	2.284***
- Class III Technology	4.212***	4.048***	3.994***

Note: 1. Fitted values at sample means, 2- * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Estimations.

4 results

Hungary

Figure 3. Productivity and technical change for Hungarian crop farms, by class, 2001 to2014



Source: Estimations.

4 results

Hungary

3 distinct classes of dairy farms

- relative evenly distributed
- class 3 largest
- all dimensions (indices) are significantly important for identification
- highly significant production functions
- significant productivity differences between classes
- technical change significantly varies between classes
- significant scale effects for two classes, slightly decreasing scale effects for largest class (46%)
- switching technologies could result in higher productivity and technical change for some farms

4 results

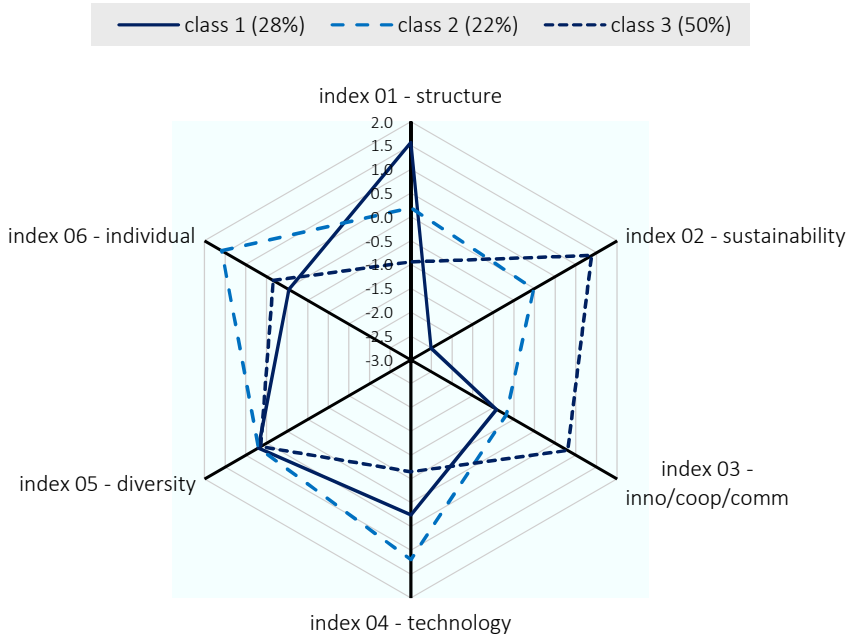
Hungary

Table 10. Class identification - mean values indices, Hungarian crop farms
Mean values[1]

	Class I	Class II	Class III
Index 1 - Structure	1.5599	0.1918	-0.9417
Index 2 - Sustainability	-2.5095	-0.0209	1.3831
Index 3 - Innovation/Cooperation/ Commercialisation	-0.9220	-0.6861	0.8020
Index 4 - Technology	0.2543	1.1934	-0.6512
Index 5 - Diversity	0.6970	0.6940	0.6380
Index 6 - Individual	-0.0450	1.5820	0.3370
Index 7 - Location	0.0146	-0.0160	-0.0011

Note: 1. At class means, scaled values.
Source: Estimations.

Figure 4. Indices for Hungarian crop farms
Scaled values at class means, 2001 to 2004



Source: Estimations.

4 results

Hungary

Table 11. Descriptive statistics by class, Hungarian crop farms
Deviations from sample means[1]

	Class I (n = 3933)	Class II (n = 3057)	Class III (n = 7138)
Production structure			
Family labour (hour per year)	282.906	-1.678	-155.161
Land (ha)	-48.471	-66.682	55.265
Sole ownership (probability)	0.023	0.063	-0.039
Sustainability			
Chemicals use (EUR per ha)	10.128	-4.833	-3.512
Organic (probability)	-3.14E-03	2.26E-03	7.63E-04
Environmental subsidies (EUR per ha)	-67.563	-96.512	60.561
Innovation / Commercialisation			
Net investment ratio (per total assets)	9.06E-03	1.36E-03	7.31E-03
Share Land Rented	-0.012	-7.16E-03	9.46E-03
Biofuel production (probability)	3.26E-03	4.12E-03	-3.56E-03
Technology			
Labour / capital ratio (hour per EUR)	2.183	2.408	-2.234
Materials per ha (EUR per ha)	10.297	30.685	-18.815
Labour per ha (hour per ha)	2.218	23.773	-11.403
Diversity			
Herfindahl Index (sqrt[Σ(yi/Y)2])	0.013	1.43E-03	-7.43E-03
Livestock production (probability)	-0.043	-0.028	0.036
Other output (probability)	-0.035	-0.053	0.042
Individual			
Age (years)	-1.101	2.179	-0.327
Off-Farm work (probability)	-0.01	0.015	-6.82E-04
Location			
Less Favoured Area (probability)	-0.011	5.18E-03	3.91E-03
Nitrate Vulnerable Zone (probability)	0.022	-0.021	-3.21E-03

Note: 1. Deviations from sample means (=0), scaled values.
Source: Estimations.

4 results

Hungary

class #1

- (most) productive farms with most significant technical change
- highest share of family labor and below average farm size (strong irts)
- above average probability of single ownership
- low score on sustainability (based on indicators)
- lowest share of rented land but higher than average prob for bioful production
- medium to high labor and other inputs intensity
- specialised farms, low other non-agricultural output generation
- younger farmers, and average off-farm income importance
- least likely located in less-favored areas but likely in nvzs

4 results

Hungary

class #2

- least productive and lowest technical change
- lower than average share of family labor but also smallest farms (weak irts)
- highest probability of single ownership
- relatively high sustainability (based on indicators)
- lower share of rented land, low investments but highest prob of bioful prod
- highest labor intensity, but also high intensity for other inputs
- average diversified, significant prob for off-farm income, bit older than average
- most likely in less-favored areas, least likely in nvzs

4 results

Hungary

class #3

- highly productive, but medium technical change
- lowest importance of family labor and most likely more than one owner
- significantly larger than average size (weak drts)
- high sustainability (based on indicators)
- highest share of rented land
- most capital intensive, least labor intensive
- highest level of diversification
- lower than average probability of off-farm income

4 results

Hungary

summary

- farms‘ performances depend on a multitude of factors (structural, behavioural and external)
- within the crop sector distinct classes of farms can be identified along a multi-dimensional scale
- these classes significantly vary with respect to their economic performance and their technical development over time
- innovative crop farms are likely to be also more productive, but not a strong correlation
- family driven and smaller farms can be innovative (cl1)
- highly sustainable crop farms are most likely located in less-favored areas (cl2 & 3)
- capital intensity and low labor use is positively correlated with farm size (cl3)
- crop farm productivity is not linked to farm size, nor to family labor share or ownership (cl1 & 3)
- more sustainable crop farms also show to be less productive (cl2)

4 results

Italy

.. productivity & technical change

Table 12. Characteristics of Italian crop farms, by class
Latent Class Estimation, Panel 2008 to 2015

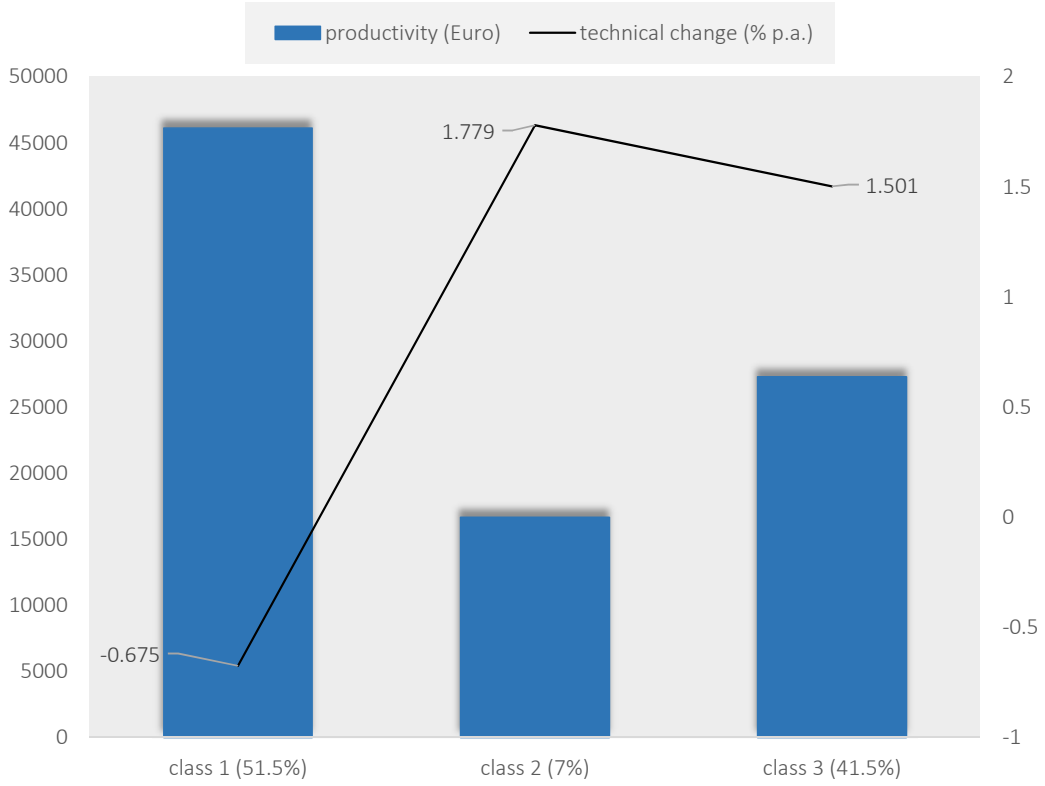
	Class I	Class II	Class III
Number of observations (% of sample farms)	10756 obs. (51.5%)	1432 obs. (7%)	8659 obs. (41.5%)
Prior probability of class membership	0.3959	0.2616	0.3424
Posterior probability of class membership	0.4197	0.2455	0.3347
Productivity level (EUR per year.) [1]			
- Class I Technology	46 101.5*** [2]	26 225.8***	36 395.5***
- Class II Technology	31 796.1***	16 653.6***	26 019.5***
- Class III Technology	32 503.4***	18 538.1***	27 266.1***
Technical Change (% per year)			
- Class I Technology	-0.675***	-0.465***	-0.881***
- Class II Technology	1.917***	1.779***	2.273***
- Class III Technology	1.863***	1.433***	1.501***

Note: 1. Fitted values at sample means, 2- * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Estimations.

4 results

Italy

Figure 5. Productivity and technical change for Italian crop farms, by class, 2008-2015



Source: Estimations.

4 results

Italy

3 distinct classes of crop farms

- 2 large classes beside a minor class
- class 1 largest
- most dimensions (indices) are significantly important for identification
- highly significant production functions
- significant productivity differences between classes
- technical change significantly varies between classes
- significant negative scale effects for two classes, positive scale effects for largest class (51%)
- switching technologies could result in higher productivity and technical change for some farms

4 results

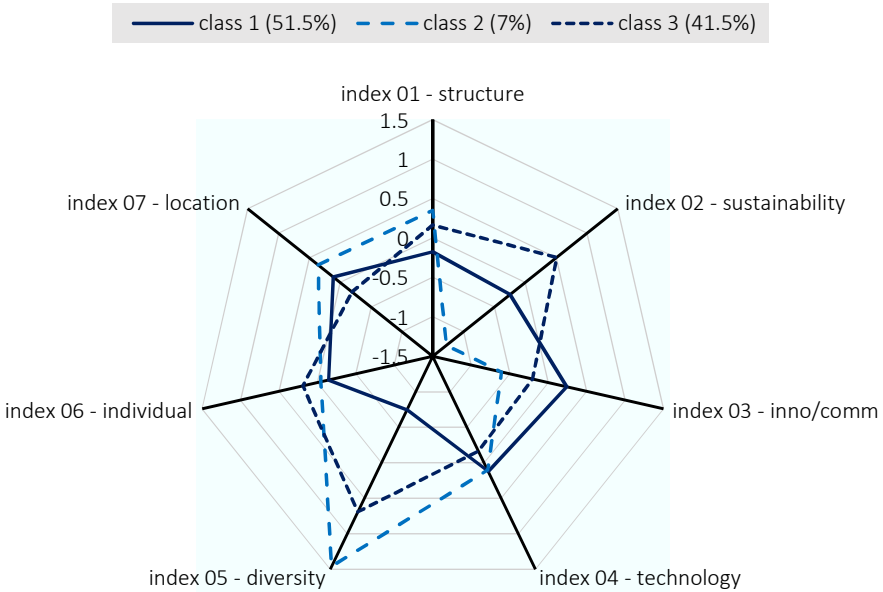
Italy

Table 13. Class identification - mean values indices, Italian crop farms
Mean values[1]

	Class I	Class II	Class III
Index 1 - Structure	-0.1764	0.3482	0.1629
Index 2 - Sustainability	-0.0247	-0.1281	0.0511
Index 3 - Innovation/Cooperation/ Commercialisation	0.2429	-0.6062	-0.2041
Index 4 - Technology	0.1207	0.1024	-0.1657
Index 5 - Diversity	-0.7459	1.4586	0.6909
Index 6 - Individual	-0.1459	-0.0469	0.1881
Index 7 - Location	0.1094	0.3591	-0.1927

Note: 1. At class means, scaled values.
Source: Estimations.

Figure 6. Indices for Italian crop farms
Scaled values at class means, 2008 to 2015



Source: Estimations.

4 results

Italy

Table 14. Descriptive statistics by class, Italian crop farms
Deviations from sample means[1]

	Class I (n = 10756)	Class II (n = 1432)	Class III (n = 8659)
Production structure			
Family/hired labour ratio	-0.1698	0.2696	0.1672
Land (ha)	0.0287	-0.0714	-0.0242
Form ownership: (1-self-employment, 2-legal person, 3-cooperative form)	0.0839	-0.2041	-0.0715
Sustainability			
Chemicals use (EUR per ha)	0.1152	0.0732	-0.1543
Organic (probability)	0.0811	-0.1071	-0.0833
Environmental subsidies (EUR per ha)	0.0259	0.0277	-0.0365
Innovation / Commercialisation			
Net investment ratio (per total assets)	0.0007	0.0263	-0.0051
Share land rented	0.1783	-0.4169	-0.1542
Cooperation (probability)	0.0469	-0.0641	-0.0478
Irrigated area ratio	0.1956	-0.4756	-0.1663
Agritourism (probability)	-0.1055	0.3419	0.0761
Technology			
Capital / labour ratio (EUR per hour)	0.0459	0.0495	-0.0648
Capital per ha (EUR per ha)	0.0534	0.1047	-0.0827
Materials per ha (hour per ha)	0.1158	0.0083	-0.1446
Total assets (EUR)	0.0005	0.0189	-0.0036
Diversity			
Herfindahl Index (sqrt[Σ(yi/Y)2])	0.5234	-0.7752	-0.5244
Production diversity (yc/ΣY)	0.5285	-1.2447	-0.4559
Forestry (probability)	-0.0626	0.3334	0.0243
Individual			
Age (years)	-0.1401	0.0221	0.1699
Education (1:primary, 2: secondary, 3: high, 4: college 1st, 5: college 2nd)	0.0688	0.0648	-0.0955
Gender (1-male, 0-female)	0.0122	-0.1770	0.0131
Location			
Less Favoured Area(1 not to- 3 severely disadvantaged)	0.0831	0.2331	-0.1401
Altitude (1: <300m, 2: 300-600m, 3: >600m)	0.0716	0.2747	-0.1324

Note: 1. Deviations from sample means (=0), z-scores based, scaled values. *Source*: Estimations.

4 results

Italy

class #1

- farms in class I are the most productive operations, however, showing a slightly negative annual technical change rate
- lowest share of family labour in the sample, higher than average farm size and still experiencing increasing returns to scale
- most probably non-single owners
- score slightly lower on sustainability than the average crop farm in Italy

  (sustainability indicators used: chemicals used, organic production, and environmental subsidies received)
- highest share of rented land and a slightly higher net investment rate than the average crop farm
- more likely to cooperate, have the highest share of irrigated land but are least likely to be engaged in agritourism
- high capital and material intensity, most specialised and least likely to diversify into non-agricultural
- farm managers are younger and better educated, off-farm income is of average importance
- more likely located in less-favoured areas and at higher altitudes

4 results

Italy

class #2

- least productive but positive technical change (of about 1.8% per year)
- highest share of family labour across all crop farms but smallest in terms of land size exhibiting
- decreasing returns to scale
- most likely a single owner and score lowest on sustainability (depending on sustainability indicators used)
- high input intensity but also most likely and significantly diversified in their production and have a high probability of being engaged in forestry production
- farm manager is a bit older than average
- farm most likely located in less-favoured and high altitude areas of Italy

4 results

Italy

class #3

- nearly half as productive as farms in class I with positive rate of technical change (of about 1.5% per year)
- family labour is important and likely the farm is owned by a single person or family
- farms in this class are slightly less endowed with land than the average crop farm in Italy but negative scale effects
- farms operate with the highest sustainability of all farms in the sample (depending on sustainability indicators used)
- a lower than average share of rented land and are least input intensive
- less diversified than the average crop farm in Italy
- farm managers are significantly older, and these farms are less likely to be located in less favoured areas and areas of high altitude

4 results

Italy

summary

- a multitude of factors correlate with the farms’ relative performance over time
- given model specification and dataset used, three distinct technology classes are identified applying various multi-dimensional indices
- crop farms in Italy significantly vary with respect to their economic performance and their technical development over time
- innovative farms are also more likely to be productive
- family driven and smaller farms in terms of acreage are not necessarily more sustainable
- highly sustainable crop farms in Italy are most likely located in lower altitudes and least likely in less-favoured areas
- capital intensive operations are negatively correlated with the farms’ sustainability, whereas diverse farms are not necessarily operating with a higher sustainability
- productivity of Italian crop farms is clearly linked to the farm's production structure (approximated by farm size, family labour share, and form of ownership)
- results suggest that sustainable crop farming in Italy is not clearly correlated with a lower or higher productivity in economic terms

4 results

Czech Republic

.. productivity & technical change

Table 15. Characteristics of Czech dairy farms, by class
Latent Class Estimation, Panel 2005 to 2015

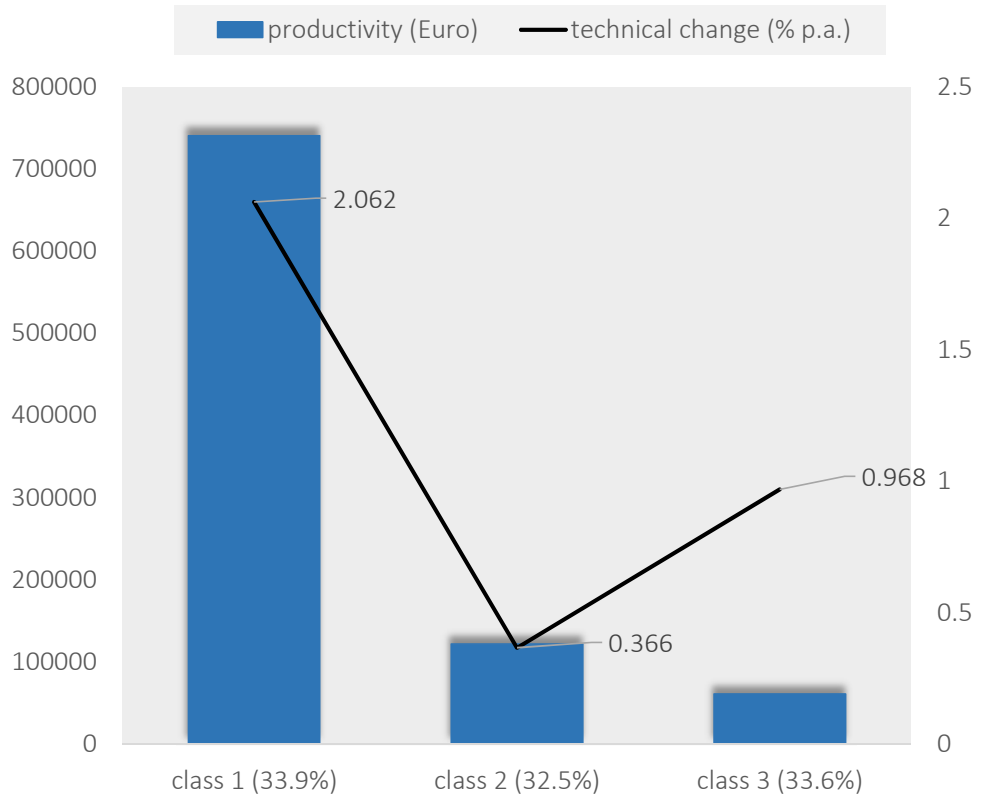
	Class I	Class II	Class III
Number of observations (% of sample farms)	343 obs. (33.9%)	328 obs. (32.5%)	340 obs. (33.6%)
Prior probability of class membership	0.5183	0.4486	0.0331
Posterior probability of class membership	0.3356	0.3265	0.3379
Productivity level (EUR per year)[1]			
- Class I Technology	740 489.2*** [2]	323 957.1***	165 440.4***
- Class II Technology	577 559.3***	121 463.2***	39 567.6***
- Class III Technology	685 885.7***	173 627.3***	60 892.6***
Technical Change (% per year)			
- Class I Technology	2.062***	6.149***	9.627***
- Class II Technology	1.944***	0.366***	-2.836***
- Class III Technology	1.873***	1.695***	0.968***

Note: 1. Fitted values at sample means, 2- * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Estimations.

4 results

Czech Republic

Figure 7. Productivity and technical change for Czech dairy farms, by class, 2005 to 2015



Source: Estimations.

4 results

Czech Republic

3 distinct classes of dairy farms

- farms are evenly distributed across 3 classes
- class 1 most productive farms
- all dimensions (indices) are significantly important for identification
- highly significant production functions
- significant productivity differences between classes
- technical change significantly varies between classes (2% | 1% | 0.4% p.a.)
- significantly positive scale effects for all classes, largest scale effects for 2nd class (1.202)
- switching technologies could result in higher productivity and technical change for majority of farms

4 results

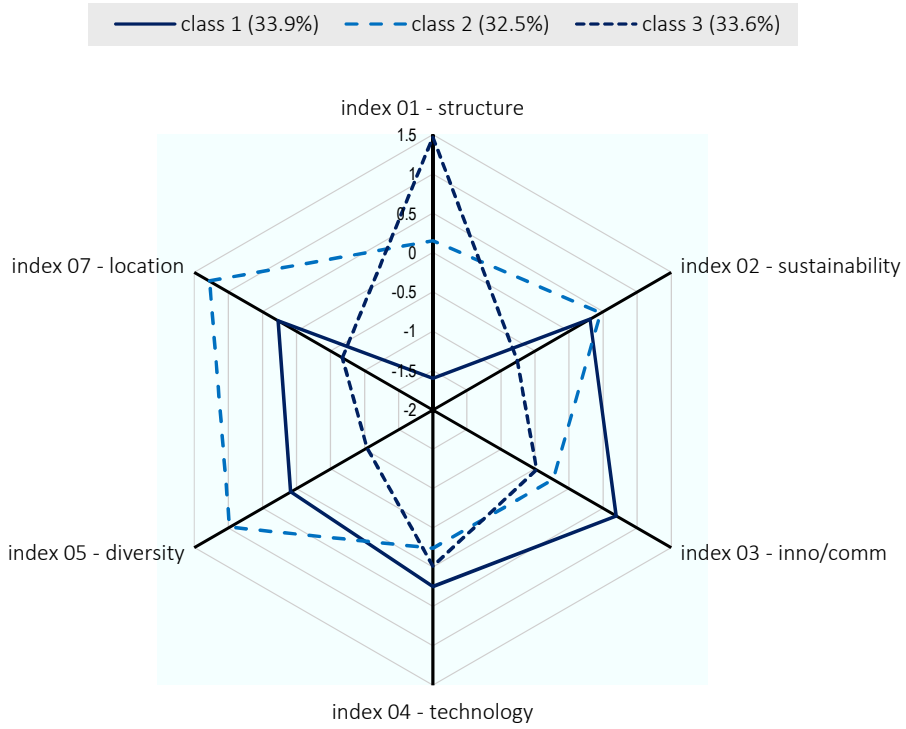
Czech Republic

Table 16. Class identification - mean values indices, Czech dairy farms
Mean values[1]

	Class I	Class II	Class III
Index 1 - Structure	-1.5974	0.1502	1.4666
Index 2 - Sustainability	0.3087	0.4622	-0.7574
Index 3 - Innovation/Coop/ Comm	0.6923	-0.2304	-0.4761
Index 4 - Technology	0.245	-0.2415	-0.0142
Index 5 - Diversity	0.0865	0.9826	-1.0353
Index 6 - Individual			
Index 7 - Location	0.2703	1.2756	-0.6735

Note: 1. At class means, scaled values.
Source: Estimations.

Figure 8. Indices for Czech dairy farms
Scaled Values at Class Means, 2005 to 2015



Source: Estimations.

4 results

Czech Republic

Table 17. Descriptive statistics by class, Czech dairy farms
Deviations from sample means[1]

	Class I (n = 343)	Class II (n = 328)	Class III (n = 340)
Production structure			
Family/hired labour ratio	-0.2094	-0.0952	0.3031
Herd size (LU)[2]	0.9596	-0.2041	-0.7711
Land (ha)	0.8898	-0.0860	-0.8147
Form of ownership (1-self-employment, 2-legal person, 3-cooperative)	0.8975	0.0022	-0.9075
Sustainability			
Stocking density (LU/ha)	-0.1833	-0.3750	0.5466
Chemicals use (Euro per ha)	0.6963	-0.2225	-0.4878
Organic (probability)	-0.2018	0.2034	0.0074
Environmental subsidies (Euro per ha)	0.2933	0.2883	-0.5740
Innovation / Commercialisation			
Net investment ratio (per total assets)	0.3282	-0.1347	-0.2011
Share land rented	0.6768	-0.0705	-0.6148
Biofuel Income (Euro)	0.3300	-0.1452	-0.1928
Technology			
Capital / labour ratio (Euro/AWU)	-0.0768	-0.1241	0.1972
Capital per cow (Euro/LU)	0.0282	-0.1361	0.1029
Labour per cow (AWU/LU)	0.0921	0.2656	-0.3492
Total assets (Euro)	0.8588	-0.2256	-0.6487
Diversity			
Herfindahl Index (sqrt[Σ(yi/Y)2])	-0.1083	-0.6264	0.7135
Production diversity (yc/ΣY)	-0.0020	-0.7632	0.7506
Individual			
Age (years)	0.2623	0.0023	-0.2669
Location			
Less Favoured Area (subsidies in Euro)	0.4644	0.2244	-0.6849
Altitude (1- <300m, 2- 300-600m, 3- >600m)	-0.0822	0.3633	-0.2676

Note: 1. Deviations from sample means (=0), z-scores based, scaled values. 2. LU: Livestock Unit.
Source: Estimations.

4 results

Czech Republic

class #1

- farms in class I are most productive and exhibit a significant positive technical change rate per year
- lowest share of family labour (i.e. a significantly lower family per hired labour share than the average farm in the sample) and significantly above average herd and acreage size but still experience (modest) increasing returns to scale
- farms in class I score relatively high on sustainability indicating characteristics

  (such as stocking density, chemicals usage and probability of producing organic)
- farms show the highest scores on innovation and commercialisation with a significantly higher than average investment rate, rented land share, and income generated by biofuels production
- lower than average capital per labour intensity, using more capital per cow than the average dairy farm in the Czech Republic (based on high levels of total assets endowment)
- farms are less diversified, their managers are older than the average dairy farmer in the Czech Republic and are most likely located in less-favoured areas

4 results

Czech Republic

class #2

- dairy farms in class II are medium productive but show a lower than average technical change per year
- hired labour is important for those farms which are smaller than the average dairy farm in the Czech Republic in terms of herd size and land endowment and a single ownership is still likely for these farms
- farms in class II should significantly increase the size of their production operations due to measured economies of scale
- farms are most sustainable based on various sustainability indicators
- dairy farms in class II invest less than the average dairy farm in the Czech Republic and generate less income by biofuel production
- capital intensity is the lowest of all dairy farms, and they employ most labour per cow
- farms are least specialised and their farm managers are of average age
- farms in class II are likely located in less-favoured areas or areas of higher altitude

4 results

Czech Republic

class #3

- class III farms are least productive but show a significant average technical change rate per year
- family labour is most important for those dairy farms which are considerably smaller than the average dairy farm in the Czech Republic in terms of herd size and land endowment
- single ownership is most likely for these farms
- farms in class III should increase the size of their production operations to become more profitable due to identified positive economies of scale
- least sustainable based on various sustainability indicators
- farms in invest far less than the average dairy farm in the Czech Republic and generate least income from biofuel production
- capital intensity is the highest of all dairy farms and farms employ least labour per cow
- farms are least diversified and their farm managers are of lower than average age
- farms in class III are less likely located in less-favoured areas or areas of higher altitude

4 results

Czech Republic

summary

- findings for dairy farming in the Czech Republic suggest that dairy farms' performances depend on a multitude of factors with respect to technology, structure, production behaviour and external conditions
- economically distinct classes of dairy farms can be statistically identified based on robust measures along a multi-dimensional scale of characteristics
- farms in the individual technology classes significantly vary with respect to their economic performance as well as technical development over time
- innovative dairy farms in the Czech Republic are most likely more productive compared to their peer group
- family driven farms and comparatively smaller farms not necessarily show a higher sustainability based on the measures used in the empirical analysis
- highly sustainable dairy farms most likely show a very diverse production structure and are most likely located in less-favoured areas with a lower than average capital intensity
- farms' capital intensity is positively correlated with herd size, while farms' productivity is correlated with herd size and the share of hired labour
- more sustainably producing Czech dairy farms can also exhibit a very high productivity, *ceteris paribus*.

5 summary

Table 18. Correlations per country and farm type

	Dairy farms		Crop farms	
Possible correlation[1]	Estonia (2000-2015)	Czech Republic (2005-2015)	Hungary (2001-2014)	Italy (2008-2015)
Innovation and productivity	+	+	+	+
Size and productivity	+	+	+/-	+
Intensity and productivity	+			
Hired labour and productivity	+		+/-	+
Sustainability and productivity	-	+/-	-	+/-
Family farming and sustainability	+	+/-		+/-
Diversity and sustainability	+			+/-
Intensity and sustainability	-			-
Less Favoured Area and sustainability	+	+	+	-

Note: 1. The signs indicate possible correlations (not causalities) subject to data and modelling. Potential cross-correlations (i.e. covariances) have to be kept in mind, despite the modelling controls for such to a large extent.
Source: Estimations.

5 summary

- it is important to keep in mind that these indicate possible correlations given data availability and applied modelling
- strong evidence of a positive correlation between innovation and productivity at farm level is found for both types of farming
- results imply some evidence for a positive correlation between farm size and the productivity of operations and between the labour structure and farm productivity
- less conclusive empirical evidence is found with respect to farm sustainability:
  - a location in less favoured areas appears to be positively correlated with the sustainability of operations for most farms
  - however, there is only limited evidence of a correlation between family farming and sustainability
  - same holds for a possible correlation between the intensity of production and sustainability (a negative correlation for two country cases) and for a possible correlation between production diversity and sustainability
  - with respect to productivity and sustainability there is some evidence (for two country cases) of a potentially negative correlation which holds for both types of production

6 way ahead

- country cases of this first phase of the project are all located in the European Union
- for the second phase of the project additional country cases are also envisaged
- the following countries have agreed to contribute in the 2nd phase: Korea, Norway, Denmark, France and Chile
- the following countries have expressed ongoing interest to participate: the United Kingdom, the Netherlands, Ireland, and Switzerland
- second phase of this project also aims to extend the empirical analyses, covering:
  (1) potential switches of farms between different technology classes over time, and
  (2) evaluating specific policy responses with respect to individual technology classes
- primary policy interest to provide empirical evidence on what types of farms actually switch to more productive technologies or adjust input mixes within the same technology given various production settings

many thanks

2nd phase

Korea

preliminary results - 1st run

7 preliminary results - 2nd phase

Korea

.. productivity & technical change

Table x. Characteristics of Korean rice farms, by class
Latent Class Estimation, Panel 2003 to 2015

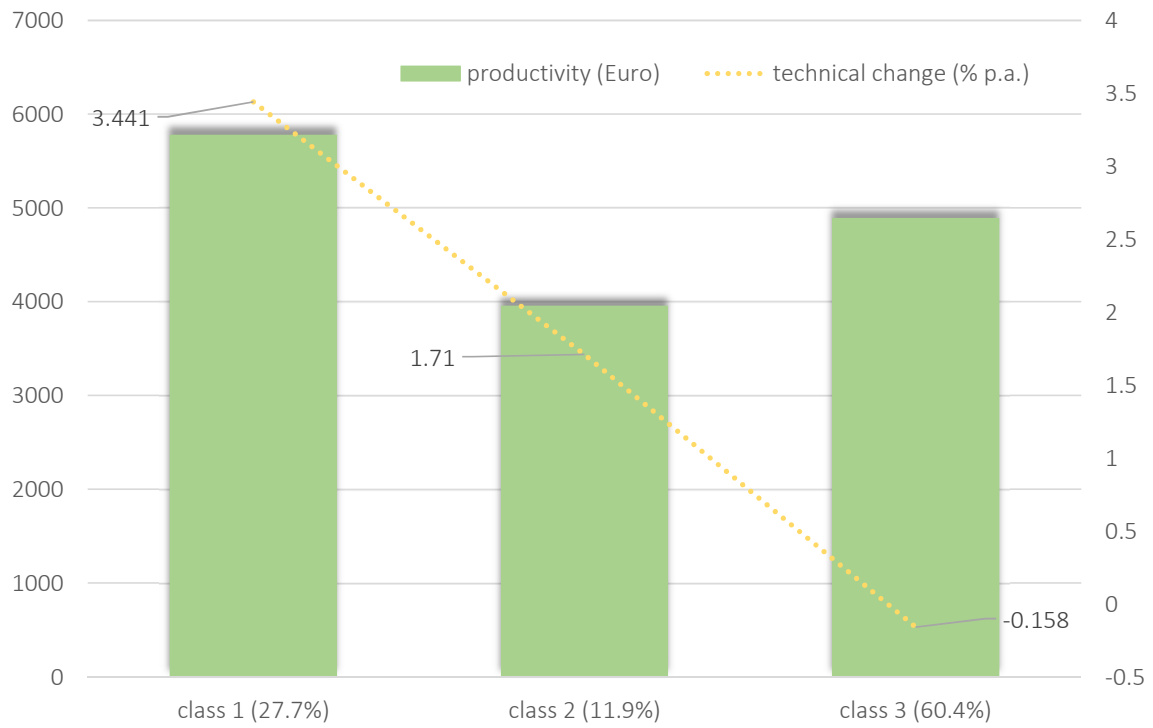
	Class I	Class II	Class III
Number of observations (% of sample farms)	4521 obs. (27.7%)	1953 obs. (11.9%)	9862 obs. (60.4%)
Prior probability of class membership	0.2872	0.1952	0.5177
Posterior probability of class membership	0.3143	0.2239	0.4618
Productivity level (EUR per year) [1]			
- Class I Technology	5773.7*** [2]	6278.4***	5983.5***
- Class II Technology	3161.7***	3949.9***	3913.8***
- Class III Technology	4549.9***	4309.1***	4885.2***
Technical Change (% per year)			
- Class I Technology	3.441***	2.777***	3.892***
- Class II Technology	-2.140***	1.711***	-2.893***
- Class III Technology	1.761***	2.918***	-0.158***

Note: 1. Fitted values at sample means, 2- * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Estimations.

7 preliminary results

Korea

Figure x. Productivity and technical change for Korean rice farms, by class, 2003 to 2015



Source: Estimations.

7 preliminary results

Korea

3 distinct classes of rice farms

- relatively uneven distribution
- class #3 largest
- all dimensions (indices) are significantly important for identification
- highly significant production functions
- significant productivity differences between classes
- technical change significantly varies between classes
- decreasing or constant returns to scale
- switching technologies could result in higher productivity and also higher technical change for most farms (and vice versa)

7 preliminary results

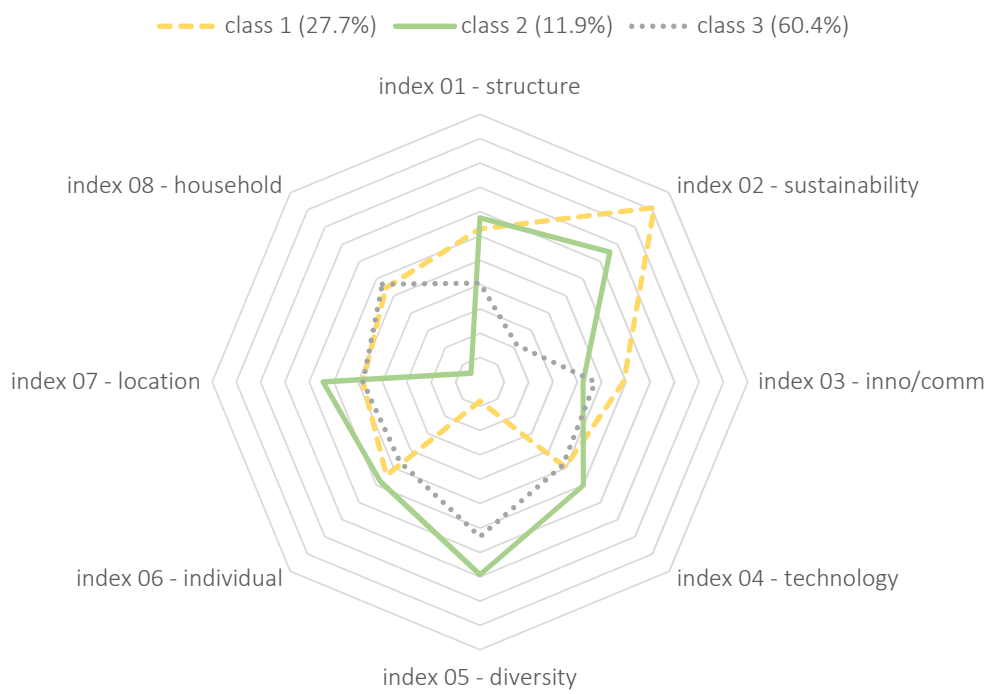
Korea

Table x. Class identification - mean values indices, Korean rice farms
Mean values[1]

	Class I	Class II	Class III
Index 1 - Structure	0.2572	0.3497	-0.1872
Index 2 - Sustainability	0.1026	0.0511	-0.0572
Index 3 - Innovation/Cooperation/Comm	0.1824	-0.1537	-0.0532
Index 4 - Technology	-0.0109	0.2010	-0.0348
Index 5 - Diversity	-0.8441	0.5837	0.2713
Index 6 - Individual	0.0854	0.1543	-0.0697
Index 7 - Location	-0.0391	0.2883	-0.0390
Index 8 - Household	0.0935	-0.8976	0.1349

Note: 1. At class means, scaled values.
Source: Estimations.

Figure x. Indices for Korean rice farms
Scaled values at class means, 2003 to 2015



7 preliminary results

Korea

Table x. Descriptive statistics by class, Korean rice farms
Deviations from sample means[1]

	Class I (n = 4521)	Class II (n = 1953)	Class III (n = 9862)
Production structure			
Family labour (hour per year)	.186072	.197099	-.124332
Land (ha)	-.177676	-.297509	.140368
Sustainability			
Chemicals use (Won per ha)	-.061486	-.10348	.048679
Eco-material use (Won per ha)	.083614	-.031194	-.032154
Innovation / Commercialisation			
Net investment (Won per ha)	.014194	-.030527	-.000461
Share Land Rented	.06163	-.032835	-.02175
Contract farming (probability)	.451019	-.34011	-.139406
Off-Farm Income (Won)	.370885	-.368586	-.097031
Technology			
Labor / capital ratio (hour per Won)	-.00415	-.084469	.01863
Capital / land ratio (Won per ha)	-.02678	.122581	-.011998
Material / land ratio (Won per ha)	.014542	.156804	-.037719
Total Assets (Won)	-.091184	.08398	.02517
Diversity			
Herfindahl Index (sqrt[Σ(yi/Y)2])	.549231	-.288439	-.194662
Production diversity (ratio rice/total output)	.6444	-.537003	-.189066
Individual			
Age (years)	-.116632	-.133699	.079944
Education (high/college/graduate)	.150045	.018193	-.072388
Location			
Catchment or Upland (probability)	-.039149	.288313	-.039149
Mountaineous region (probability)	-.10499	-.059592	.06101
Productive region (probability)	-.020852	-.102516	.032059
Household			
Female/male labor ratio (n)	-.061506	.932259	-.156422
Family members (n)	.070744	-.337143	.034334

Note: 1. Deviations from sample means (=0), scaled values.
Source: Estimations.

7 preliminary results

Korea

class #1

- most productive farms with most significant technical change
- high share of family labor
- below average acreage size
- high score on sustainability (based on indicators)
- highest investment per farm and significant prob for cooperation but also off-farm income
- lower than average capital intensity, but about average labor per capital rate
- highly specialized farms
- younger and better educated farmers
- less likely to be located in less-favored areas
- female/male labor ratio slightly below average

7 preliminary results

Korea

class #2

- least productive farms with lowest rate of technical change
- highest share of family labor and lowest acreage size per farm
- good score on sustainability (based on indicators)
- lowest investment per farm and also significantly below average prob for cooperation and off-farm income
- highly intensive technology, especially for the capital per land rate
- most diverse production
- farmers are younger of medium education
- rice farms are less likely to be located in „productive“ areas but most probably cultivate catchment and upland fields
- female/male labor ratio the highest in the sample with lowest family size

7 preliminary results

Korea

class #3

- medium productive farms with slightly positive technical change per year
- lowest share of family labor but highest acreage size per farm
- lowest score on sustainability (based on indicators)
- average investment per farm and also below average prob for cooperation and off-farm income
- least intensive technology, especially with respect to the labor per capital rate
- significantly diverse production
- farmers are older and of comparatively low education
- female/male labor ratio below average
- average family size

7 results

Korea

summary

- rice farms‘ performances depend on a multitude of factors (structural, behavioural and external)
- within the rice sector distinct classes of farms can be identified along a multi-dimensional scale
- these classes significantly vary with respect to their economic performance and their technical development over time
- innovative rice farms are very likely to be also more productive, here: a strong correlation
- family driven and smaller farms show low productivity but good sustainability (cl2)
- highly sustainable rice farms are least likely located in less favorable production areas (cl1)
- capital intensity and diversity of production negatively correlated with acreage of rice farm (cl2)
- rice farm productivity not necessarily correlated with acreage and labor structure (cl1 versus cl3)
- more sustainable rice farms are not necessarily less productive (cl1 and cl2)

many thanks