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Influence of heat and drought stress on economic efficiency and resilience of EU dairy farms

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Introduction

- Increasing challenges at farm level in the context of climate change
- Heat and drought stress are two key climate related challenges at farm level, often impacting the production and economic performance
- limited evidence on the association of climate challenges and dairy farm performance
- Economic efficiency and resilience are relevant indicators of performance

➡ **What is the influence of heat and drought stress on economic efficiency and resilience on EU dairy farms ?**

In the frame of the H2020 project Gentore (GENomic management Tools to Optimize Resilience and Efficiency) (2017-2022)

Data

- FADN database from 2007 to 2013
- Panel data of 4,669 individual farms in 24 EU countries
- Performance measurement : technical efficiency and economic resilience
- Output expressed in milk yield per dairy cow
- Inputs expressed in constant monetary values (2013)
- Climate indicators : regional heat and drought stress (derived from the Agri4cast database)

Steps

- Use of a Latent Class model (Orea and Kumbhakar, 2004) to assign NUTS2 regions to climatic classes that represent similar production environments

- Estimation of technical efficiency and economic resilience by class using a panel stochastic frontier model (Battese and Coelli,1995) and a downside risk parameter (Chavas, 2008), respectively

- Evaluation of the influence of heat and drought stress on efficiency and resilience using regression models

(Unit of analysis: dairy cow)

Efficiency methodology (1)

- Cobb-Douglas functional form: underlying assumption of constant returns to scale tested (Abdulai and Huffman, 2000)
- Time-varying model with true fixed-effects (Greene, 2005)
- Half-normal distribution for the inefficiency term (Kumbhakar et al. 2015).
- Input variables:
  - Feed
  - Forage
  - Machinery
  - Labour
  - Others

Efficiency methodology (2)

- In the frame of the SF panel model, the effect of climatic stress on the inefficiency term is investigated (combined estimation process)

- Climatic regressors :
  - number of periods of at least 40 consecutive dry days (<3mm/day)
  - the same variable but with a lagged effect (previous year)
  - the number of periods of at least 3, 10, or 20 consecutive days, depending on the class characteristics, with a Temperature Humidity Index (THI) strictly above 60

    $THI=(1.8xTdb+32)-[(0.55-0.0055xRH)x(1.8+Tdb-26.0]$ *(NRC, 1971)*

- Additional regressors
  - farm size (UAA)
  - stocking density
  - dairy specialisation rate
  - price of milk (/dt)

Economic resilience methodology

- Downside risk calculated on an annual basis for each farm

  = actual gross margin – average gross margin over 2007-2013

- Tobit panel data model (dependent variable right censored at the 0 value) (Tobin, 1958)

- Same climatic and additional regressors as in efficiency analysis

Class splitting

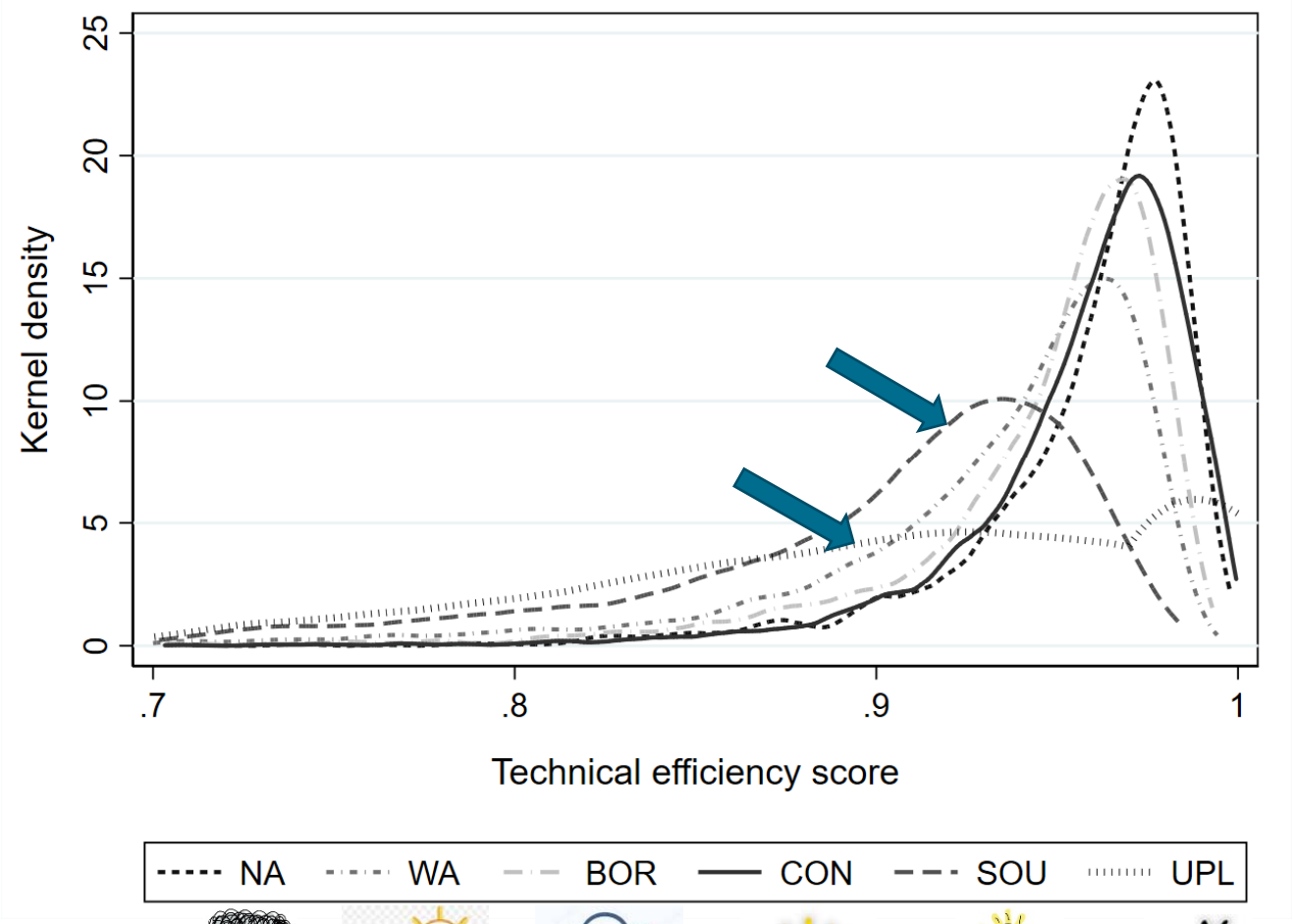





ZONE	North Atlantic (NA)	West Atlantic (WA)	Boreal (BOR)	Continental (CON)	Southern (SOU)	Mountain / Upland (UPL)
Description	Cool and wet, with little temperature variation	Moderate temperature, with warmer summers, cooler winters	Very cold winters, moderate summer, dry	Warm summers, cold winters	Hot summers, cool winters	Relatively warm summers and cool winters, variable rainfall
Production (kg/cow)	**5,842**	**7,259**	**8,624**	**5,981**	**6,818**	**6,366**
Farm size (ha)	**77**	**76**	**71**	**65**	**49**	**47**

Technical efficiency score (0;1)

- High average efficiency scores: from 0.88 in class SOU and UPL to 0.95 in class NA and CON
- Flatter efficiency distribution in class SOU and UPL



Influence of drought and heat stress on inefficiency (0;1)

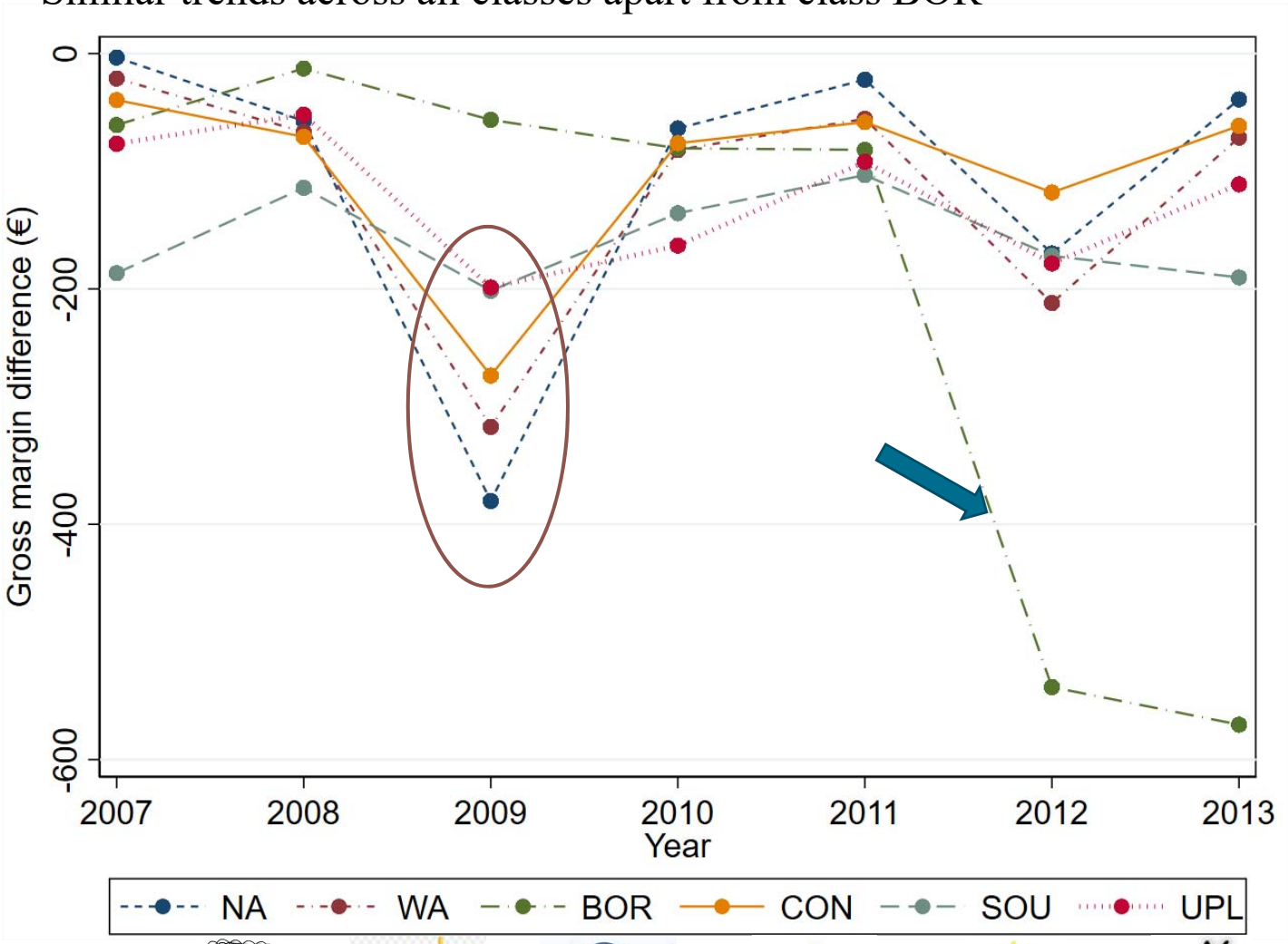





Class	NA	WA	BOR	CON	SOU	UPL
Observations	2,366	9,611	1,596	13,174	2,135	3,801
Individual farms	338	1,373	228	1,882	305	543
Periods ≥ 40 consecutive dry days	-0.072	**0.448***	0.389	-0.111	0.322	**0.691****
Lagged periods ≥ 40 consecutive dry days	**4.471*****	0.327		-0.349	0.205	**0.662****
Periods ≥ 3 consecutive hot days	**0.811*****					
Periods ≥ 10 consecutive hot days		**0.495*****	**0.368*****	-0.02		**-0.182***
Periods ≥ 20 consecutive hot days					**0.858****	
Farm size	-0.015	**-0.010*****	**-0.013*****	-0.02	-0.001	-0.001
Stocking density	**-0.273***	**0.222*****	**-0.187*****	-0.119	**0.080*****	0.092
Specialisation	**-0.062*****	**-0.040*****	**-0.055*****	**-0.070*****	**-0.046****	**-0.030*****
Milk price	0.007	**0.084*****	**0.171*****	**0.074*****	**0.067*****	**0.034*****
Constant	-1.229	**-5.584*****	**-7.613*****	-2.408	**-5.042*****	**-2.851*****

Resilience outcome

- Similar trends across all classes apart from class BOR



Influence of drought and heat stress on economic resilience (€/cow)






Class	NA	WA	BOR	CON	SOU	UPL
Observations	2,366	9,611	1,596	13,174	2,135	3,801
Individual farms	338	1,373	228	1,882	305	543
Periods ≥ 40 consecutive dry days	191.138***	93.092***	-95.305***	-70.072***	-112.083***	-74.846***
Lagged periods ≥ 40 consecutive dry days	-227.229***	-107.284***		-112.079***	-0.649	-61.779***
Periods ≥ 3 consecutive hot days	-98.508***					
Periods ≥ 10 consecutive hot days		-11.277***	-23.034***	30.204***		29.761***
Periods ≥ 20 consecutive hot days					-169.897***	
Farm size	-0.553***	0.233***	-0.216***	-0.516***	0.065***	0.051***
Stocking density	7.944***	-6.289***	44.136***	-16.735***	-4.926***	-19.858***
Specialisation	0.846***	-0.962***	17.617***	0.170***	6.108***	2.511***
Milk price	38.243***	40.286***	2.198***	13.228***	4.857***	11.465***
Constant	-1,123.333***	-1,331.317***	-1,447.720***	-395.127***	-273.006***	-588.608***

Conclusions

- Technical efficiency:
  - ✓ High technical efficiency of farms in the EU dairy sector
  - ✓ Little influence of drought
  - ✓ Significant negative influence of the heat across all classes apart from class UPL

➡ Little scope for efficiency improvement, but heat stress adaptation strategies need to be further considered

- Economic resilience:
  - ✓ Significant negative influence of the drought across all classes, but less clear in class NA and WA
  - ✓ Significant negative influence of the heat across all classes apart from class CON and UPL

➡ Clear threats to economic resilience, requiring adaptation strategies

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Thanks for your attention !

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