UNIVERSITÄT BONN

Agricultural policy evaluation using micro data

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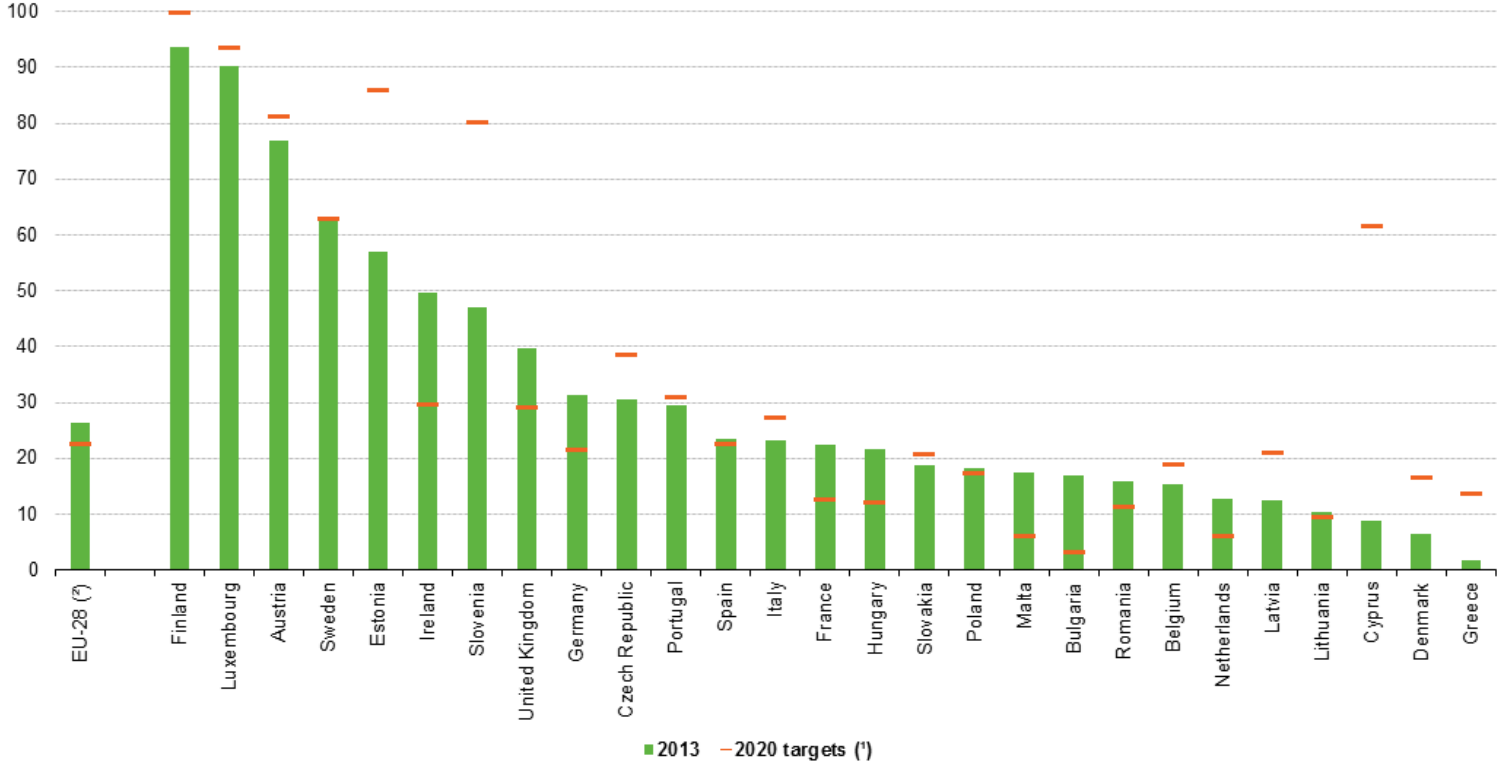
Agri-environmental schemes - windfall or incentives?



Eurostat https://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_commitments

Environmental impact of AES: Germany

DID-Matching (Pufahl&Weiss 2009; Arata & Sckokai 2016)

P&W: bookkeeping data

- 2000-2005
- ATTs:
  - Fertilizer 9.4% ↘
  - Pesticide 4.7% ↘
  - Grassland share 9% ↗

80% treated farms excluded to reduce covariate bias

A&S:FADN

- 2003-2006
- ATTs:
  - Fertilizer € 33/ha or 89% ↘
  - Pesticide 0% ➡
  - Grassland share 0% ➡

Subsamples: share of AES-payments on farm income > 5%

→ 8 treated farms for Germany

Causal impact of AES participation

Outline:

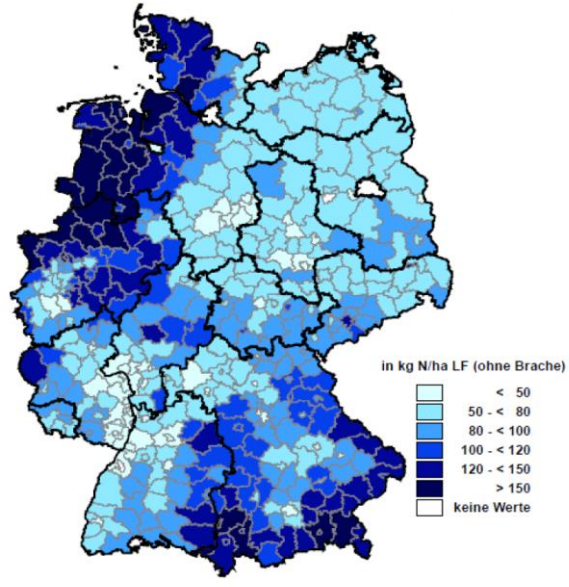
1. DID-Matching and implicit assumptions about the causal relationship
2. Data & Empirical Strategy
3. Results
4. Concluding Remarks

Case Study: Western Germany

Objectives and procedure

1. Provide theoretical framework for application of DID-matching
   → underlying assumptions for CIA to hold

2. Quantify causal impact of AES participation
   → Representative evidence for whole first period 2000-2006



N-balance 2003;
Source: Osterburg, RAUMIS-simulation 2007

Recall DID-Matching

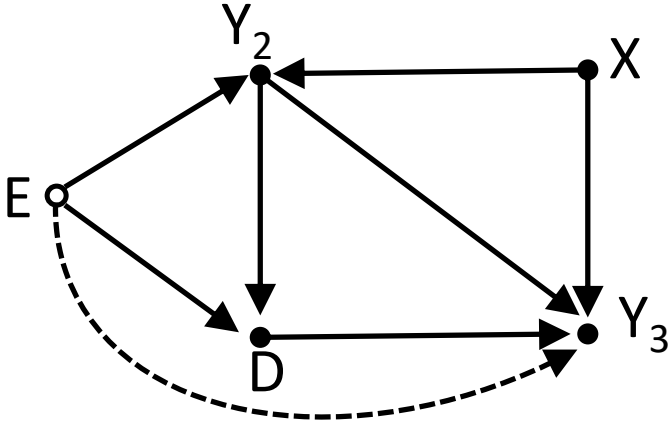
Selection on observables and unobservables

- DID unbiased if selection determined by an unobserved time constant fixed effect (PTA)
- Matching unbiased if selection determined by time variant observables

- Combining DID with matching might capture the influence of both types of confounders (Abadie, 2005; Blundell, Dias, Meghir, & van Reenen, 2004; Heckman et al., 1997, 1998).

Impact of AES: Qualitative causal model

- Estimate the causal effect of D on Y_3: **$D \rightarrow Y_3$**
- Identification via blocking of noncausal paths between D and Y_3



- Noncausal path between D and Y_3: **$D \leftarrow E \rightarrow Y_2 \leftarrow X \rightarrow Y_3$** shows that Y_2 is a collider (Elwert & Winship, 2014).
- Noncausal paths **$E \rightarrow Y_2$** and **$E \rightarrow D$** blocked by conditioning on Y_2 and X.

- E affects Y_2 then it also effects Y_3 by definition

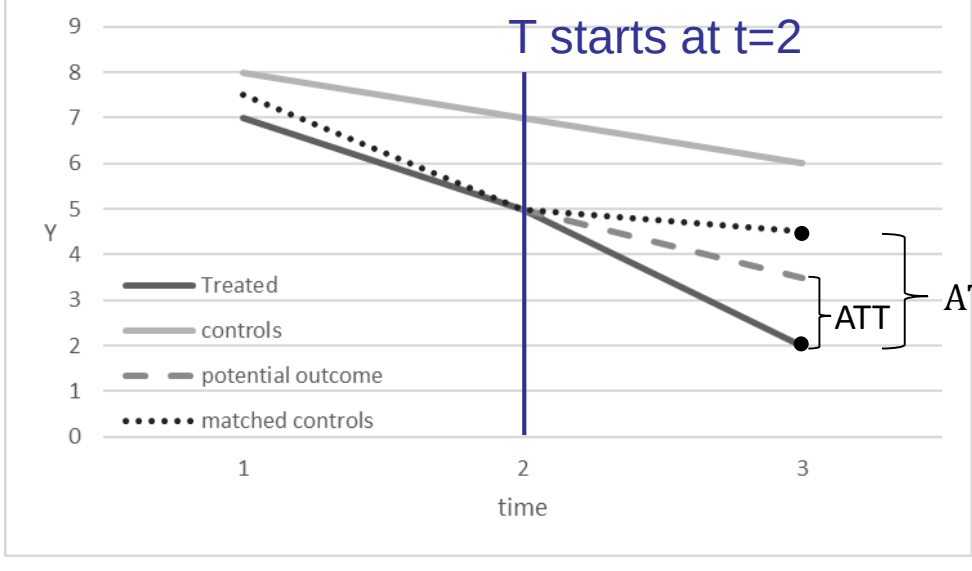
  → Causal effect is not identified via conditioning on Y_2 and X.

Matching with unobservable cofounders

Environmental preferences determine selection and outcome:

- Farms with absent EP do not participate
- Their Y trend diverges from potential outcome trend of treated

  → ATT inconsistent, in this case overestimated

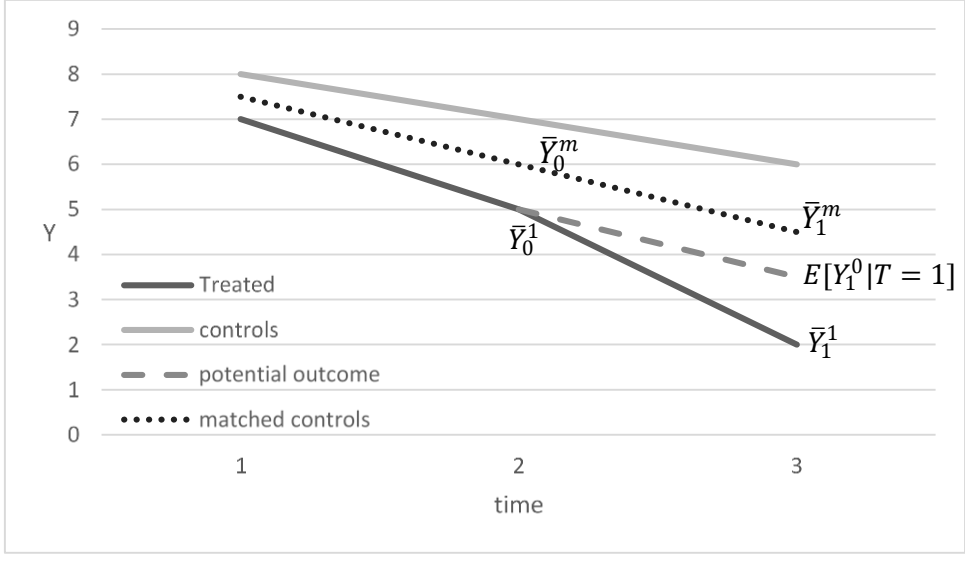


$$\mathrm{ATT}^{M} = \left(Y^{1} \middle| D = 1, S\right) - E\left(Y^{0} \middle| D = 0, S\right)$$

DID-Matching: Selection on unobservables

- Matched controls used to estimate the treatment effect via DID
- Matched controls likely to be more similar to the treated
  → makes the PTA more plausible.

$$ATT = \widehat{ATT}^{DID\_m} = (\bar{Y}_1^m - \bar{Y}_0^m) - (\bar{Y}_1^1 - \bar{Y}_0^1)$$



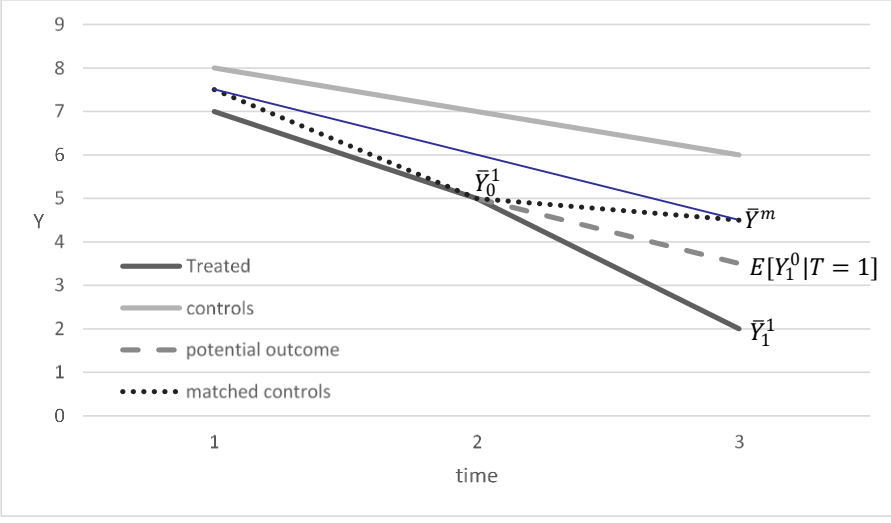
Caution: PTA must still hold

ability to reduce could determine selection → if effect of ability increases over time → PTA fails and $\widehat{\mathrm{ATT}}^{\mathrm{DID\_m}}$ biased

DID-Matching: The pre-treatment outcome

DID-Matching on pre-treatment outcome results in covariate balance of the pre-treatment outcome: $\bar{Y}_0^1 = \bar{Y}_0^m$

→ biased estimator (Chabé-Ferret 2015, 2017)



$$\widehat{ATT}^{DID\_m} = (\bar{Y}^m - \bar{Y}_0^1) - (\bar{Y}_1^1 - \bar{Y}_0^1)$$
$$= \bar{Y}^m - \bar{Y}_1^1 = \widehat{ATT}^m$$

→ Nothing added to simple matching!

→ Potentially breaks PTA

DID-Matching: Procedure

Selection equation

- Variables affecting participation (P&W 2009, A&S 2016, Z&B2016):
  - **Farm characteristics**: size, share of rented land, grassland, capital intensity, productivity, lfa and region.
  - **Production portfolio**: farm type, livestock densities and cropping shares.

DID-Matching

- 5 year differences
- 3 participation cohorts → max N
  - Y_i^{pre}: year before uptake (1999, 2000, 2001)
  - Y_i^{post}: year when contract finishes (2004 , 2005 , 2006)
- Exact matching on year and farm type

AES participation

- No vineyards, horticulture
- No switchers
- Year of first participation

Year	Share of AES farms	N
2000	57%	1504
2001	63%	1587
2002	44%	697
2003	34%	445
2004	31%	408
2005	21%	266
2006	25%	421

Production programme

Production intensity

AES Participation (0/1)	Entry year		
	2000	2001	2002
Age of farmer	1.00	1.00	1.00
Land input (ha)	1.01**	1.00	1.01**
Land input (ha) squared	1.00*	1.00	1.00
Share of grassland area	1.78	1.83	3.72***
Share of rented land	2.38***	1.50**	1.66***
Share of cereals area	0.60	0.95	0.37***
Share of permcrop area	3.00	0.82	0.88
Cattle (LU/ha)	1.92**	0.99	0.86
Cattle (LU/ha) squared	0.77**	0.92	1.00
Cattle (LU/ha)# Share of grassland area	0.58	0.86	0.46***
Pigs and poultry (LU) per ha	1.24***	0.96	0.99
Sales per hectare	1.00**	1.00*	1.00**
Revenue per working unit	1.00	1.00	1.00
Revenue per capital	0.91	0.92*	0.98
Fixed capital per hectare	1.00	1.00**	1.00*
Fertilizer expenditure per hectare	1.00	1.00***	1.00
Plant protection expenditure per hectare	1.00	1.00*	1.00
Direct payments crops per hectare	1.00***	1.00***	1.00***
Direct payments livestock per hectare	1.00***	1.00***	1.00***
LFA participation (0/1)=1	1.59***	1.17	1.06
Farmtype (Base=Crop)			
Livestock	0.63*	0.90	1.37*
Livestock crop mixed	0.97	1.27*	1.47***
Region (Base=South)			
West	0.04***	0.41***	0.39***
North	0.03***	0.09***	0.07***
Participation bef. 2000			
Yes	23.22***	2.85***	2.68***
unknown	8.96***	1.35***	1.98***
Observations	4302	4507	4531
Pseudo R^2	0.624	0.274	0.294

Exponentiated coefficients, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Matching estimators: results

Matching Estimator	Matched Treated	Matched Controls	ATT (bs. s.e.)	95% CI
NN Mahalanobis matching				
1:1 NN Mahalanobis Matching	957	328	-0.27*** (0.105)	[-.48; -.07]
1:5 NN Mahalanobis Matching	957	854	-0.30*** (0.105)	[-.50; -.10]
Kernel Matching bandwidth selection Method				
R∗quantdist method (1.5∗90% Quantile)	941	1465	-0.28*** (0.103)	[-.48; -.08]
Cross validation . w.r.t. means of X	293	377	-0.26 (0.222)	[-.70; .17]
Weighted cross validation w.r.t. means of Y a)	475	491	-0.43** (0.210)	[-.84; -.02]
N Total	957	1565		

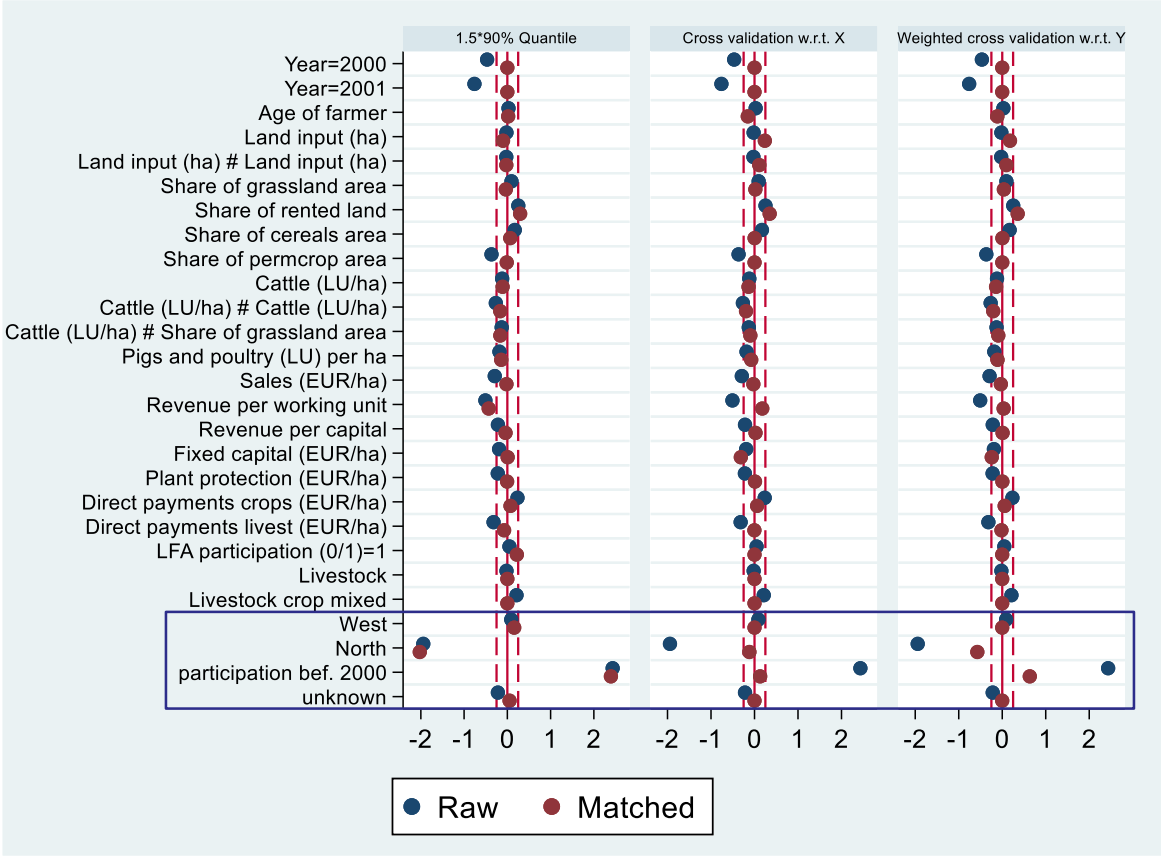
Notes: Outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate, * p < 0.1, ** p < 0.05, *** p < 0.01
a) Galdo et al. 2008

- Outcome: **fertilizer exp.**
- Size depends on estimator
- One case not significant
  → efficiency?

- Estimator choice:
  → Covariate balance via stand. mean difference
  → Varying cutoff values:
  10% (Rosenbaum and Rubin 1985)
  5% (Caliendo and Kopeinig 2008)
  25% (Rubin 2001, Harder et al. 2010)

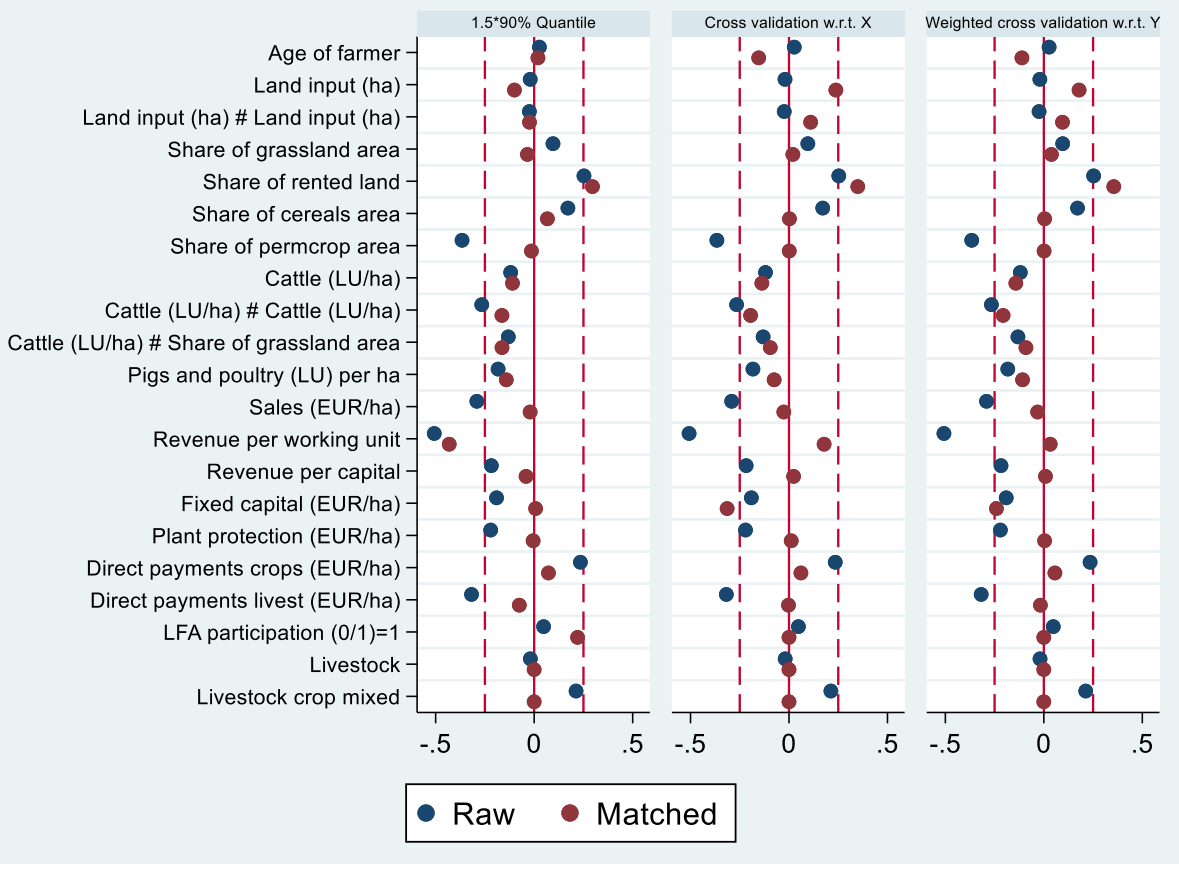
Effects calculated using kmatch: Jann, B. (2017). kmatch: Stata module for multivariate-distance and propensity-score matching.

Covariate balance: mean stand. difference



- Cross validation techniques balances region and pre-participation much better

Covariate balance: mean stand. difference



- Unbalance on share of rented land and fixed capital / hectare

Environmental outcomes

Matching Estimator	Fertilizer Expenditure [a]		Plant Protection Expenditure [a]		Share of grassland change [b]	
	ATT (bs. s.e.)	95% CI	**ATT (bs. s.e.)**	95% CI	**ATT (bs. s.e.)**	95% CI
1:1 Mahalanobis Matching	**-0.27*** (0.105)**	[-.48; -.07]	-0.17 (0.105)	[-.52; .18]	**0.03*** (0.010)**	[.01; .04]
Cross validation . w.r.t. means of X	-0.26 (0.222)	[-.70; .17]	-0.19 (0.348)	[-.87; .48]	**0.04** (0.016)**	[.01; .07]
Weighted cross validation w.r.t. means of Y [a]	**-0.43** (0.210)**	[-.84; -.02]	**-0.34** (0.253)**	[-.84; 15]	**0.02** (0.009)**	[-.00; .03]

Notes: Outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, a) Galdo et al. 2008 b) outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate c) outcome in percentage points, e.g. mean difference is interpreted as change in percentage points

Environmental outcomes: by subgroups

Crop farms: No effects

Matching Estimator	Fertilizer Expenditure [a]		Plant Protection Expenditure [a]		Share of grassland change [b]	
	ATT (bs. s.e.)	95% CI	**ATT (bs. s.e.)**	95% CI	**ATT (bs. s.e.)**	95% CI
1:1 Mahalanobis Matching	**-0.81*** (0.219)**	[-1.5; -.15]	0.10 (0.234)	[-.36; .57]	0.01 (0.008)	[-.00; .03]
Cross validation . w.r.t. means of X	-0.08 (0.201)	[-.47; .31]	-0.08 (0.143)	[-.20; .36]	-0.00 (0.006)	[-.01; .01]
Weighted cross validation w.r.t. means of Y [a]	-0.27 (0.236)	[-.97; -.17]	0.00 (0.143)	[-.27; .28]	0.01 (0.007)	[-.00; .02]
Naïve	-0.21		-0.00		0.00	

Notes: Outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, a) Galdo et al. 2008 b) outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate c) outcome in percentage points, e.g. mean difference is interpreted as change in percentage points

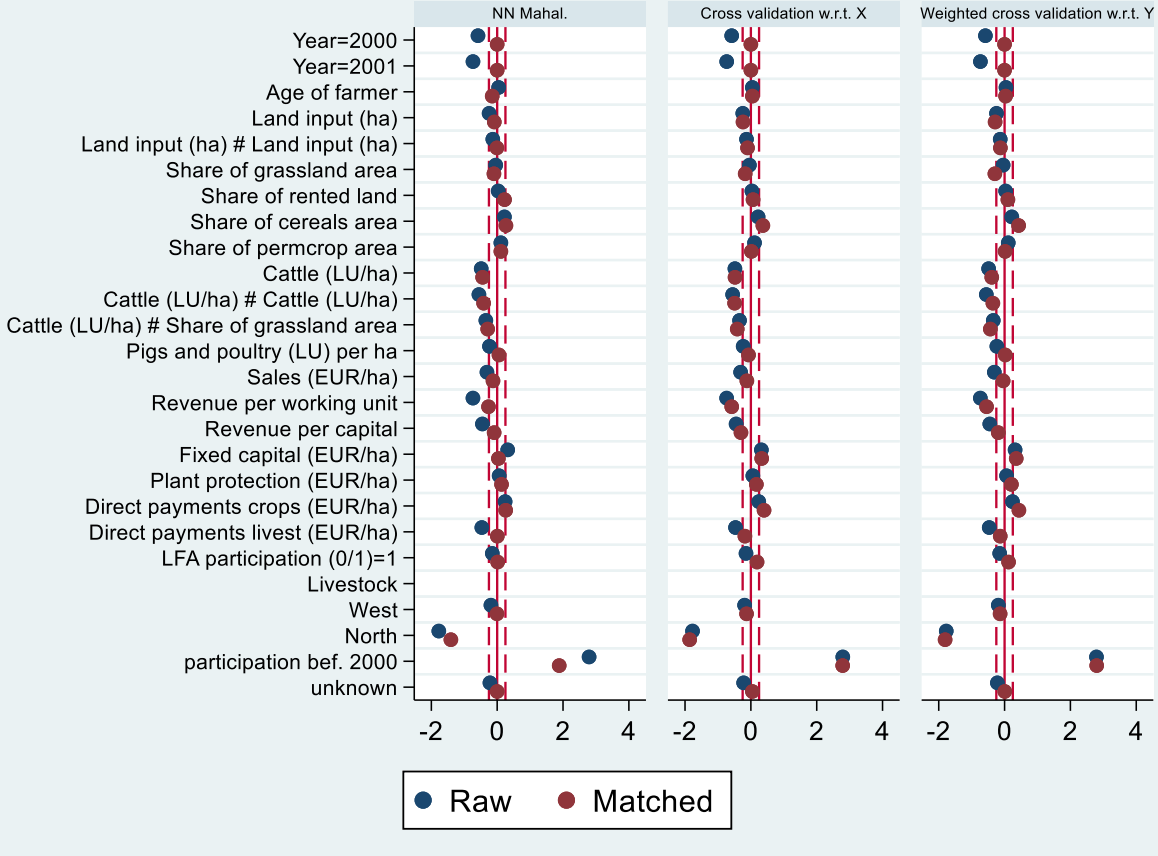
Environmental outcomes: by subgroups

Livestock farms: clear results

Matching Estimator	Fertilizer Expenditure [a] ATT (bs. s.e.)	95% CI	Plant Protection Expenditure [a] ATT (bs. s.e.)	95% CI	Share of grassland change [b] ATT (bs. s.e.)	95% CI
1:1 Mahalanobis Matching	**-0.48*** (0.219)**	[-.91; -.05]	-0.34 (0.294)	[-.92; .23]	**0.05*** (0.013)**	[.02; .07]
Cross validation . w.r.t. means of X	**-0.50** (0.194)**	[-.88; -.12]	-0.20 (0.236)	[-.67; .25]	**0.02*** (0.007)**	[.00; .03]
Weighted cross validation w.r.t. means of Y [a]	**-0.57*** (0.210)**	[-.97; -.17]	-0.24 (0.255)	[-.74; 26]	**0.02*** (0.007)**	[.01; .04]
Naïve	-0.54		-0.22		0.002	

Notes: Outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, a) Galdo et al. 2008 b) outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate c) outcome in percentage points, e.g. mean difference is interpreted as change in percentage points

Covariate balance: livestock farms



- Most effects for livestock farms
- Covariate balance worse for subgroups → lower N
- Further bias decrease by regression adjustment

Conclusion

- Added theory, relevant behavioral assumptions
- Substantial Causal effects for fertilizer reduction and grassland increase especially for livestock farms

- Yet, partly remaining bias in relevant covariates
- Further balancing:
  - force more balance on important covariates in selection equation
  - via subsequent regression adjustment

- Check PTA, but maybe limits due to panel lengths

References

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Appendix

Matching Estimators

- Nearest neighbor
  - Propensity Score (Rosenbaum and Rubin 1985), Mahalanobis distance (Rubin 1980)
  - Mahalanobis Distance within caliper of propensity score (Rosenbaum and Rubin 1985)
  - Trade off between bias removal and efficiency
- Kernel density
  - decreasing weight to observations further away along the distance metric
  - Crucial: bandwidth selection

Optimal bandwidth selection

- Based on a radius multiplier and the percentile of distance metric, e.g. $1.5 \times distance_{90\%\ quantile}$ (Huber et al. 2013)
- Methods based on cross-validation
  - Choose bandwidth *h* to minimize approximation to mean integrated squared error (MISE) of the estimated counterfactual mean regression function (Stone 1974)

$$MISE_c(h) = \arg\min_h \left(\left(\frac{1}{n_0} \sum_{j=1}^{n_0} (Y_{0j} - \hat{m}_{-j}(\rho_j, h)^2 \right) \right.$$

  - $\hat{m}_{-j}(\rho_j, h)$ denotes estimated cond. mean function for the untreated at ρ_j using all untreated except j

Environmental outcomes: by subgroups

Mixed farms

Matching estimator	Fertilizer Expenditure [a]		Plant Protection Expenditure [a]		Share of grassland change [b]	
	ATT (bs. s.e.)	95% CI	**ATT (bs. s.e.)**	95% CI	**ATT (bs. s.e.)**	95% CI
1:1 Mahalanobis Matching	**-0.22* (0.117)**	[-.45; -.01]	-0.24 (0.34)	[-.90; .42]	0.01 (0.014)	[-.02; .04]
Cross validation w.r.t. means of X	-0.25 (0.16)	[-.56; .01]	-0.07 (0.48)	[-1.0; .87]	0.01 (0.015)	[-.02; .04]
Weighted cross validation w.r.t. means of Y [a]	**-0.25* (0.138)**	[-.52; .02]	-0.06 (0.48)	[-.99; .87]	-0.01 (0.021)	[-.04; .04]
Naïve	0.06		0.08		0.01	

Notes: Outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, a) Galdo et al. 2008 b) outcomes in natural logarithms e.g. mean difference is interpreted as the continuous growth rate c) outcome in percentage points, e.g. mean difference is interpreted as change in percentage points