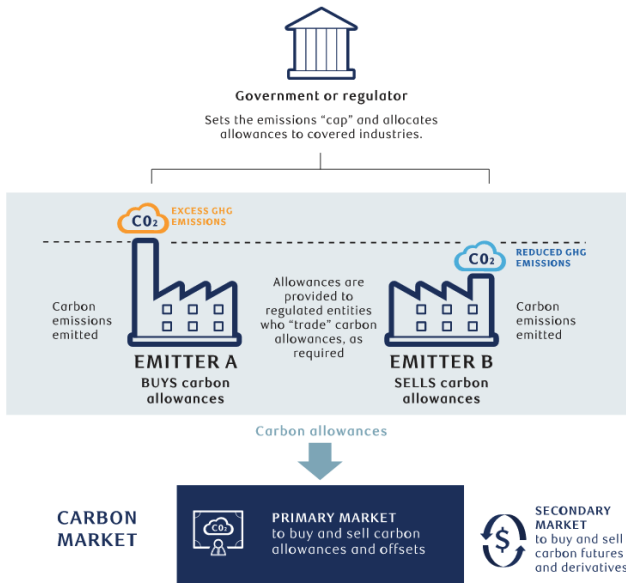# The Impact of Green Policies on Local Economic Performance: Evidence from the EU ETS
Hernandez, Mallarino & Percoco

Presenter: Gian Maria Mallarino

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The EU ETS is a cap-and-trade system

The EU ETS

- One of the world's largest carbon markets
- Inaugurated in 2005: covers 45% of the EU's greenhouse gases (GHG) emissions in 31 countries
- Four phases as of today
- Phases 1 (2005-2007) and 2 (2008-2012): decentralized, free allowances (90% of the total) based on mostly historical emissions (grand-parenting)
- Phase 3 (2013-2020): Single EU-wide cap with 57% of allowances auctioned and the rest allocated for free using EU-wide sector benchmarks

Free Allocations Across Time

Verified emissions and free allowances by year
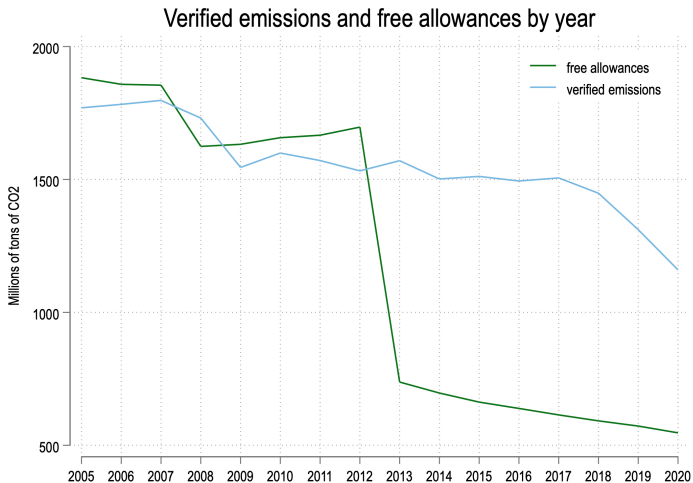
Impact of cap-and-trade carbon policies on local economic performance

Key question

What has been the impact of the EU ETS on local economic performance?

- Why? 1) Growing interest for social and economic impacts of green policies and 2) existing research on EU ETS mainly focused on companies rather than local economies

- How? Exploiting a policy change in free allocations from phase 2 to phase 3 of the policy and using both continuous and binary DiD with fixed effects using data on emissions from EU ETS registry and on local economic performances from the Regions Database from Eurostat (2021) on three outcomes: GVA, Employment and PPE

- Results: being a province more exposed to the EU ETS is associated with **negative and significant results on employment and GVA**, with marginal negative effects also on in productivity.

EU ETS Price

EU Carbon Permits

Phase 1 (2005-2007)

Phase 2 (2008-2012)

Phase 3 (2013- 2020)

source: tradingeconomics.com

Contributions to the literature

Our paper contributes to the growing literature on carbon policies on two different levels:

- **Broader literature on the effects of carbon policies** on: GDP change Bernard et al. (2018), employment Yamazaki (2017), household consumption Goulder et al. (2019), performances of industrial Bernstein et al. (2017) and manufacturing Martin et al. (2014)

- **Specific literature on the effects of cap-and-trade systems and EU ETS** see, for example: Commins et al. (2011); Costantini and Mazzanti (2012); Reinaud (2008); Yu (2011); Healy et al. (2018) Dechezleprêtre et al. (2023) and Känzig and Konradt (2023)

- In particular, we contribute to the topic on the heterogeneous spatial effects of the EU ETS (Roseta-Palma et al. (2011); Robaina and Goncalves (2019)) and by focusing on local labor markets providing for the **first time evidence for a) Phase III of the policy and b) at the NUTS3 level.**

Data on Local Economic Performance

Eurostat Regions and Cities Database

- Gross Value Added (GVA), employment
- Productivity: we build a measure of productivity per employee (GVA/EMP)
- Population, education (share of population per education level: primary, secondary, tertiary)
- Outcomes at total NUTS 3 level or only on sectors covered by ETS [1]

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[1] This includes B: mining and quarrying; C: manufacturing; D: electricity, gas, steam and air conditioning supply; E: water supply
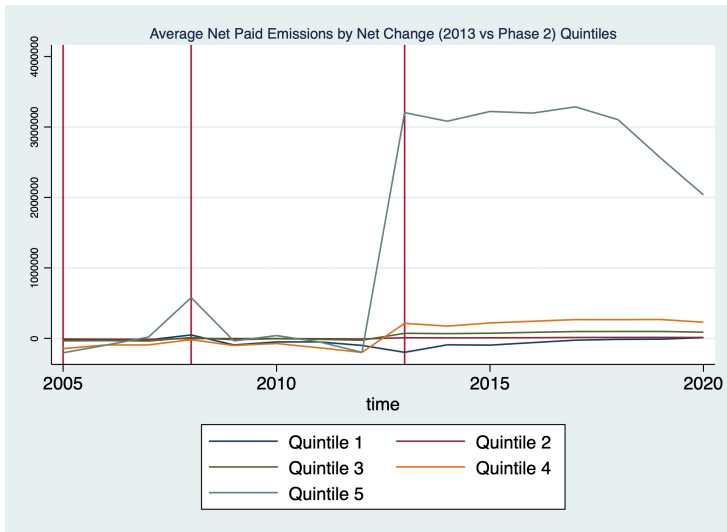
Data on CO2 Emissions

ETS emission

- CO2 emissions at the plant level from the EU Emission Trading System (EU-ETS) register are aggregated at the NUTS3 level to calculate absolute local exposure

Treatment

For each province, we compute the difference between the net paid emissions (emissions-free allowances) in 2013 and the average in phase 2
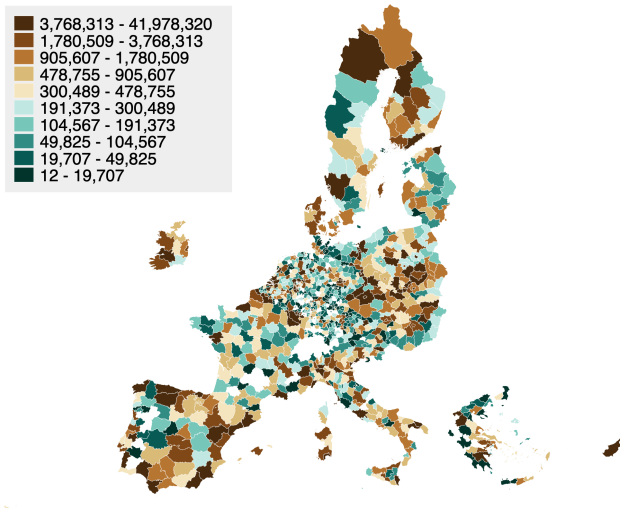
- For the first specification, we use the computed difference as the continuous measure of exposure
- For the second specification, we assign treatment status $= 1$ to quintile 5; and treatment status $= 0$ to quintiles 1-4

Change in Net Emissions Across Time by Quintile

Average Net Paid Emissions by Net Change (2013 vs Phase 2) Quintiles

Heterogeneity in emission levels: 2012 Emissions

ETS verified emissions in 2012 tCO2-eq

Legend:
- 3,768,313 - 41,978,320
- 1,780,509 - 3,768,313
- 905,607 - 1,780,509
- 478,755 - 905,607
- 300,489 - 478,755
- 191,373 - 300,489
- 104,567 - 191,373
- 49,825 - 104,567
- 19,707 - 49,825
- 12 - 19,707

Aggregated to the NUTS3 level. Data from European Union Transaction Log (EUTL)

Empirical Strategy

Continuous difference-in-differences:

$$logY_{it} = \alpha + \beta_{it}log(ETSD_i) * Post_t + \gamma_t + \lambda_i + \boldsymbol{\sigma} X_{it} + \epsilon_{it} \qquad (1)$$

Where

- i indexes NUTS3 and t the years.
- Log(Y_{it}): log of GVA, employment or PPE (GVA/EMP).
- $ETSD_i$ is the exposure: differences of net position (emissions - allowances) between 2013 and avg phase 2 in each province ("ETS dose"),
- $Post_t$ is an indicator variable for post-phase 3 start (2013 onwards)
- γ_t is a set of year fixed effects and λ_i are NUTS3 fixed effects.
- X_{it}, a vector of controls that vary over NUTS3 and time, including population and education levels.
- SEs clustered at the NUTS3 level

Identification Assumptions

Continuous DID assumptions from Callaway et al. (2021):

- iid data, support (no units treated in t-1 and continuous treatment), no simultaneous shocks, no anticipation
- **Strong parallel trends for a given level of a dose**: for all doses, the average change in outcomes over time across all units if they had been assigned that amount of dose is the same as the average change in outcomes over time for all units that experienced that dose

Empirical Strategy

Binary difference-in-differences:

$$logY_{it} = \alpha + \beta_{it}log(ETSD_i) * Post_t + \gamma_t + \lambda_i + \boldsymbol{\sigma}X_{it} + \epsilon_{it} \qquad (2)$$

Where

- i indexes NUTS3 and t the years.
- $Log(Y_{it})$: log of GVA, employment or PPE (GVA/EMP).
- $ETSD_i$ is the exposure: binary variable with quintile 5 of ETS dose = 1 (treated) and quintiles 1-4 = 0 (control),
- $Post_t$ is an indicator variable for post-phase 3 start (2013 onwards)
- γ_t is a set of year fixed effects and λ_i are NUTS3 fixed effects.
- X_{it}, a vector of controls that vary over NUTS3 and time, including population and education levels.
- SEs clustered at the NUTS3 level

Change in Net Emissions Across Time Q5 vs Rest

Average Net Paid Emissions by Net Change (2013 vs Phase 2) Quintiles

Legend: Quintiles 1-4 — Quintile 5
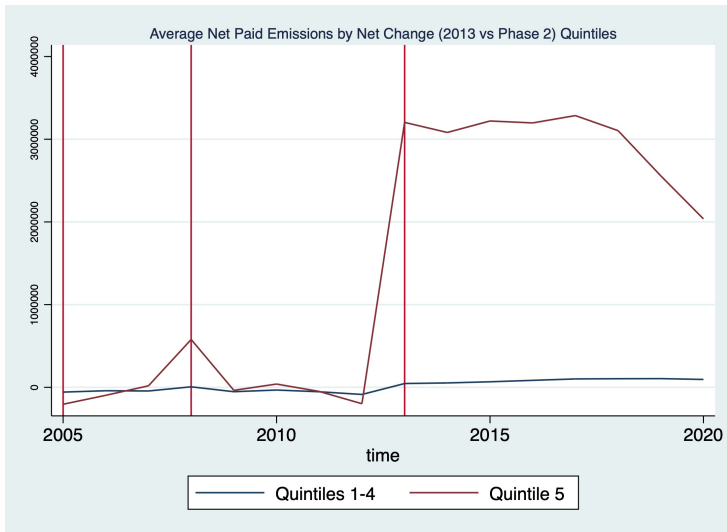
False positive and false negative exposures

Phase 2 AVG net position ("+" = emissions > allowances)	Phase 3 year 1 net position	Exposure measure	Real shock
⊕	⊖	Negative	Negative
⊕	⊖	Negative	Negative
⊕	⊕	Positive	Positive
⊕	⊕	Negative	(still) Positive
⊖	⊖	Negative	Negative
⊖	⊖	Positive	(still) Negative
⊖	⊕	Positive	Positive
⊖	⊕	Positive	Positive

- "+" refers to situations in which emissions exceeded free allocations
- "-" refers to situations in which free allocations exceeded emissions
- Results with and without false positives and false negatives are for the most part aligned

Net Change as Measure of Exposure Results: Employment

Table: Continuous difference-in-differences Estimates of Phase 3 on Employment using Net Allowance Change starting in Phase 3

	(1) Emp Tot	(2) Emp Tot No False	(3) Emp B-E	(4) Emp B-E No False	(5) Emp NOT B-E	(6) Emp NOT B-E No False
Ph3*log netchange	-0.0010***	-0.0009***	-0.0020***	-0.0020***	-0.0010***	-0.0009**
	(0.0003)	(0.0003)	(0.0006)	(0.0006)	(0.0003)	(0.0003)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	12686	10202	12686	10202	12686	10202

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Net Change as Measure of Exposure Results: GVA

Table: Continuous difference-in-differences Estimates of Phase 3 on GVA using Net Allowance Change starting in Phase 3

	(1) GVA Tot	(2) GVA Tot No False	(3) GVA B-E	(4) GVA B-E No False	(5) GVA NOT B-E	(6) GVA NOT B-E No False
Ph3*log netchange	-0.0020***	-0.0020***	-0.0032***	-0.0035***	-0.0018***	-0.0019***
	(0.0006)	(0.0006)	(0.0010)	(0.0011)	(0.0006)	(0.0006)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	12686	10202	12685	10201	12686	10202

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Net Change as Measure of Exposure Results: PPE

Table: Continuous difference-in-differences Estimates of Phase 3 on PPE using Net Allowance Change starting in Phase 3

	(1) PPE Tot	(2) PPE Tot No False	(3) PPE B-E	(4) PPE B-E No False	(5) PPE NOT B-E	(6) PPE NOT B-E No False
Ph3*log netchange	-0.0010*	-0.0011*	-0.0013*	-0.0014*	-0.0009	-0.0010*
	(0.0005)	(0.0006)	(0.0007)	(0.0008)	(0.0005)	(0.0006)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	12686	10202	12685	10201	12686	10202

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table: Difference-in-differences Estimates of Phase 3 on Employment using Net Allowance Change starting in Phase 3

	(1) Emp Tot	(2) Emp Tot No False	(3) Emp B-E	(4) Emp B-E No False	(5) Emp NOT B-E	(6) Emp NOT B-E No False
Ph3*log netchange *Q5	-0.0158***	-0.0167***	-0.0330***	-0.0333***	-0.0133***	-0.0141***
	(0.0039)	(0.0041)	(0.0067)	(0.0071)	(0.0041)	(0.0043)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	12686	10202	12686	10202	12686	10202

Standard errors in parentheses
Quintile 5 vs 1-4
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Q5 vs Q4-1. Net Change as Measure of Exposure Results: GVA

Table: Difference-in-differences Estimates of Phase 3 on GVA using Net Allowance Change starting in Phase 3

	(1) GVA Tot	(2) GVA Tot No False	(3) GVA B-E	(4) GVA B-E No False	(5) GVA NOT B-E	(6) GVA NOT B-E No False
Ph3*log netchange *Q5	-0.0312***	-0.0347***	-0.0492***	-0.0521***	-0.0281***	-0.0312***
	(0.0073)	(0.0076)	(0.0124)	(0.0130)	(0.0074)	(0.0076)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	12686	10202	12685	10201	12686	10202

Standard errors in parentheses
Quintile 5 vs 1-4
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Q5 vs Q4-1. Net Change as Measure of Exposure Results: PPE

Table: Difference-in-differences Estimates of Phase 3 on PPE using Net Allowance Change starting in Phase 3

	(1) PPE Tot	(2) PPE Tot No False	(3) PPE B-E	(4) PPE B-E No False	(5) PPE NOT B-E	(6) PPE NOT B-E No False
Ph3*log netchange *Q5	-0.0154**	-0.0181***	-0.0162*	-0.0188*	-0.0148**	-0.0171**
	(0.0067)	(0.0069)	(0.0096)	(0.0101)	(0.0072)	(0.0074)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	12686	10202	12685	10201	12686	10202

Standard errors in parentheses
Quintile 5 vs 1-4
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Recap

- Provinces with more substantial change in the amount of paid emissions see decreases in employment, GVA and productivity
- Impact visible at the sector and general local level with negative results recorded also for sectors not covered by the policy
- If this trend is confirmed, one might expect stronger effects for the current period, given the sharp increase in price
- Results are robust when extending the observation period (2005) and to sample selection for possible false positive/negative observations
- Next steps: 1) matching/synthetic DiD; 2) heterogeneous effects depending on urban/rural, workforce characteristics etc.

Thank you!
Questions?
gian.mallarino@phd.unibocconi.it

RESULTS USING 2005-2012 AS PRE-PERIOD (PHASE 1 + PHASE 2)

Net Change as Measure of Exposure Results: Employment

Table: Continuous difference-in-differences Estimates of Phase 3 on Employment using Net Allowance Change starting in Phase 3

	(1) Emp Tot	(2) Emp Tot No False	(3) Emp B-E	(4) Emp B-E No False	(5) Emp NOT B-E	(6) Emp NOT B-E No False
Ph3*log netchange	-0.0013***	-0.0011***	-0.0025***	-0.0025***	-0.0012***	-0.0010**
	(0.0004)	(0.0004)	(0.0007)	(0.0007)	(0.0004)	(0.0004)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	15520	12483	15520	12483	15520	12483

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Net Change as Measure of Exposure Results: GVA

Table: Continuous difference-in-differences Estimates of Phase 3 on GVA using
Net Allowance Change starting in Phase 3

	(1) GVA Tot	(2) GVA Tot No False	(3) GVA B-E	(4) GVA B-E No False	(5) GVA NOT B-E	(6) GVA NOT B-E No False
Ph3*log netchange	-0.0016**	-0.0016**	-0.0027**	-0.0031***	-0.0014**	-0.0014**
	(0.0007)	(0.0007)	(0.0011)	(0.0012)	(0.0007)	(0.0007)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	15520	12483	15519	12482	15520	12483

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Net Change as Measure of Exposure Results: PPE

Table: Continuous difference-in-differences Estimates of Phase 3 on PPE using Net Allowance Change starting in Phase 3

	(1) PPE Tot	(2) PPE Tot No False	(3) PPE B-E	(4) PPE B-E No False	(5) PPE NOT B-E	(6) PPE NOT B-E No False
Ph3*log netchange	-0.0003	-0.0005	-0.0002	-0.0006	-0.0003	-0.0004
	(0.0006)	(0.0006)	(0.0008)	(0.0009)	(0.0006)	(0.0007)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	15520	12483	15519	12482	15520	12483

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Q5 vs Q4-1.Net Change as Measure of Exposure Results: Employment

Table: Difference-in-differences Estimates of Phase 3 on Employment using Net Allowance Change starting in Phase 3

	(1) Emp Tot	(2) Emp Tot No False	(3) Emp B-E	(4) Emp B-E No False	(5) Emp NOT B-E	(6) Emp NOT B-E No False
Ph3*log netchange *Q5	-0.0194***	-0.0219***	-0.0379***	-0.0402***	-0.0164***	-0.0186***
	(0.0048)	(0.0050)	(0.0079)	(0.0084)	(0.0050)	(0.0052)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	15520	12483	15520	12483	15520	12483

Standard errors in parentheses
Quintile 5 vs 1-4
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Q5 vs Q4-1. Net Change as Measure of Exposure Results: GVA

Table: Difference-in-differences Estimates of Phase 3 on GVA using Net Allowance Change starting in Phase 3

	(1) GVA Tot	(2) GVA Tot No False	(3) GVA B-E	(4) GVA B-E No False	(5) GVA NOT B-E	(6) GVA NOT B-E No False
Ph3*log netchange *Q5	-0.0287***	-0.0340***	-0.0450***	-0.0498***	-0.0260***	-0.0307***
	(0.0082)	(0.0085)	(0.0133)	(0.0140)	(0.0085)	(0.0088)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	15520	12483	15519	12482	15520	12483

Standard errors in parentheses
Quintile 5 vs 1-4
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Q5 vs Q4-1. Net Change as Measure of Exposure Results: PPE

Table: Difference-in-differences Estimates of Phase 3 on PPE using Net Allowance Change starting in Phase 3

	(1) PPE Tot	(2) PPE Tot No False	(3) PPE B-E	(4) PPE B-E No False	(5) PPE NOT B-E	(6) PPE NOT B-E No False
Ph3*log netchange *Q5	-0.0093	-0.0121	-0.0071	-0.0096	-0.0096	-0.0121
	(0.0076)	(0.0079)	(0.0102)	(0.0107)	(0.0083)	(0.0086)
Population	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes
Year f.e.	Yes	Yes	Yes	Yes	Yes	Yes
N	15520	12483	15519	12482	15520	12483

Standard errors in parentheses
Quintile 5 vs 1-4
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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